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CQ VHF

Ham Radio Above 50 MHz

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Summer 2007

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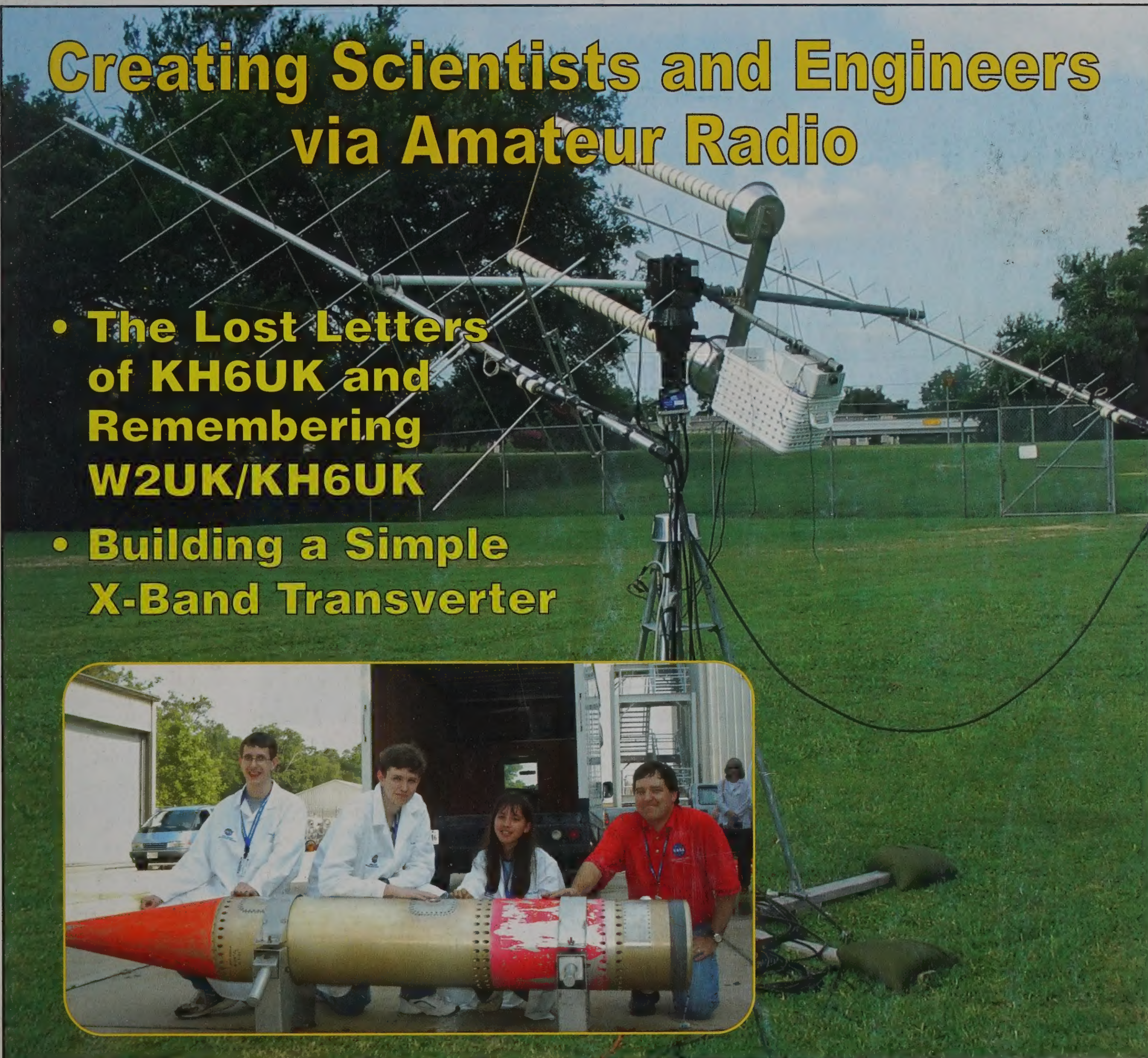
Creating Scientists and Engineers via Amateur Radio

- The Lost Letters of KH6UK and Remembering W2UK/KH6UK
- Building a Simple X-Band Transverter



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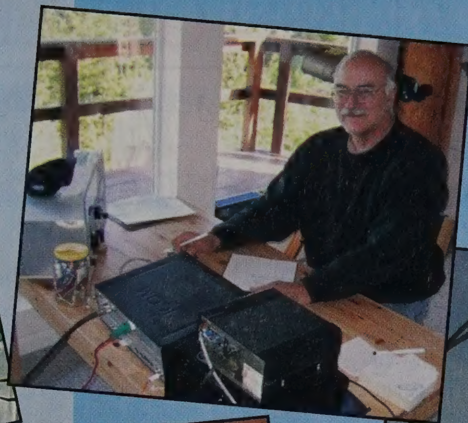

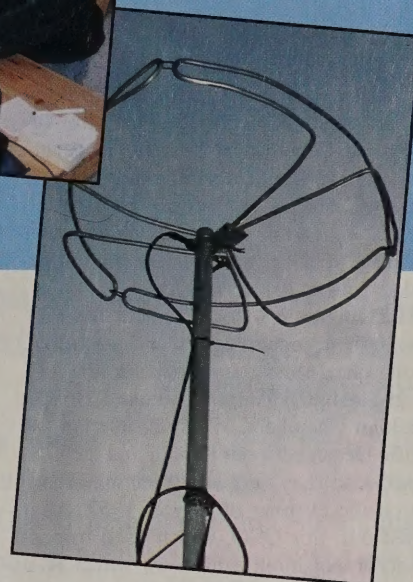

COLUMNS

DEPARTMENTS

On The Cover: This year for Field Day the AO-51 Operations Team decided to run Mode V/U FM and Mode L/U FM simultaneously. The cover photo shows the W5IU satellite array. For details see the "Satellites" column by Keith Pugh, W5IU, on page 68. (Photo by W5IU) **Inset photo:** Columbus (Georgia) High School students with a rocket payload section after recovery from the Atlantic Ocean. For more of the story see "Creating a Few Scientists and Engineers with Amateur Radio," by Luther Richardson, KI4AOJ, on page 6. (Photo courtesy of KI4AOJ)

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

History Made, Making History, and History in the Making

As the title of this editorial indicates, much of this issue of *CQ VHF* is about history. Regarding history made, it was 50 years ago this July that the International Geophysical Year (IGY) began. In actuality, it would last 18 months. It was a time of exciting worldwide propagation research that coincided with the peak of Sunspot Cycle 19, which is the highest recorded cycle to date.

Amateur radio involvement in the IGY was invited, encouraged, and recruited. Taking place almost as a sidebar to the IGY was an attempt by Tommy Thomas, KH6UK, and John Chambers, W6NLZ, to span the Pacific Ocean between Hawaii and the U.S. West Coast. They completed their initial contact on the evening of July 8, 1957. As it turned out, this QSO, which used tropospheric propagation, a mode in which IGY researchers were not initially interested, eventually earned the reputation as being perhaps the most important amateur radio contact to take place during the IGY. Along with the reputation the QSO earned Tommy and John, they also received the 1960 ARRL Merit Award and the 1961 Edison Award, for which they each were given a trophy and split a $500 cash award.

Tommy was no stranger to being in the limelight. Thanks to correspondence with his nephew Mark Shultise, WA3ZLB, the son of Tommy's sister, Freda Shultise, I have documented some of Tommy's fascinating history in an article entitled "Remembering W2UK/KH6UK," which begins on page 48. Even more important than Mark's recollections was Tommy's own documentation, which he did before and during his exploits in Hawaii. The repository of this documentation was his good friend Walter Morrison, W2CXY, who dutifully kept almost everything he received from Tommy in a file cabinet that eventually ended up in the basement of his son Mark Morrison, WA2VVY.

When Mark finally got around to rummaging through those files, he realized that he had a treasure trove of history that needed to be shared with today's amateur radio VHF-plus operators. Coincidentally, Mark chose to share what has become known as "The Lost Letters of KH6UK" with *CQ VHF* magazine at the beginning of the 50th anniversary of the IGY. Beginning on page 16 you can read the fascinating story of that history-making QSO between Tommy and John Chambers. We at *CQ VHF* are very grateful to Mark for choosing this magazine as a venue for sharing this historically significant material with the amateur radio VHF-plus community.

Thanks to Tommy and John's groundbreaking work on tropospheric ducting between Hawaii and the West Coast, numerous other QSOs have taken place over the past 50 years. Much of the successive pioneer work has been done by Paul Lieb, KH6HME, and Chip Angle, N6CA. However, eluding these two thus far is a QSO on the 10-GHz band. Regarding potential history in the making, Gordon West, WB6NOA, discusses their latest attempts beginning on page 27. Because of the increasing popularity of the 10-GHz band, another 10-GHz related article in this issue is by Wayne Yoshida, KH6WZ, beginning on page 22. This one is about an easy-to-build transverter.

Fifty years after the IGY began, amateur radio experimentation and research continues, now with a new generation of young people, which includes both college and high school students. Beginning on page 6 you can read of Luther Richardson, KI4AOJ's work with college students at Auburn University and high school students at Columbus (Georgia) High School. In particular, these students are learning about flying balloons and rockets and using amateur radio as an integral component of their experimentation.

Documenting and providing coverage of those things that involve amateur radio experimentation up in the air has been something that we at *CQ VHF* magazine have been striving to improve with each successive issue. With this issue our coverage has become significantly better thanks to veteran writer and editor Bill Brown, WB8ELK, who begins a new column entitled "Up in the Air: New Heights for Amateur Radio" (see page 54).

When we think about making history, as it was for Tommy Thomas and John Chambers, setting goals plays a significant role for so many of the rest of us who operate on the VHF-plus ham bands. The goal that Paul Kiesel, K7CW, set for himself was to improve upon the results that Bill Smith, KØCER, now WØWOI, achieved when he operated from Ketchikan, Alaska, during the 1970 ARRL June VHF QSO Party. This year Paul teamed up with Kevin O'Connell, KLØRG, to make the effort. You can read about their operation beginning on page 30.

Giving Paul and Kevin a big assist was Ed Cole, KL7UW, who is, as Paul writes, "making great efforts to popularize weak signal VHF in Alaska." I mention Ed here because in the Spring 2007 issue of *CQ VHF* magazine I let slip by a mistake in Paul Shuch, N6TX's "Orbital Classroom" column. Ed's callsign was incorrectly printed as KL7UB in the photo caption in the column. I regret the error and apologize to Ed for the mistake.

There is lots of other great reading in this issue, including the columns that you look for in each issue. One column that has been with us from the start is "Antennas," written by Kent Britain, WA5VJB. In this issue he takes a nostalgic look at antennas that were very popular in years past—and some of the models that continue to be popular today. You can read his column beginning on page 40.

In the middle of Kent's column is a new advertiser, Texas Towers. We welcome Gerald Williamson, K5GW, and his company to *CQ VHF* magazine and thank him for his advertising support. Concerning Texas Towers and all of our advertisers, it is very important that we support them by buying their products and services. One way that they get to know that the ads they place in *CQ VHF* magazine are working is by way of your feedback. Therefore, when you contact them, I ask you to please tell them that you saw their ad in *CQ VHF*. Thank you for doing so.

Following this idea of telling our advertisers that you saw their ads in the magazine, I also encourage you to tell others about the content of this magazine. Along with telling them, please also encourage them to subscribe to *CQ VHF*. It is this kind of word-of-mouth advertising that is a great method of promotion. When you tell a friend about a product or service, he or she is very likely to believe you and follow your lead because of the trust that friend has in your opinion.

Regarding feedback and opinions, we at *CQ VHF* magazine also value your feedback. What are we doing right? What else would you like to see covered in the pages of the magazine? Finally, what can we improve upon in order to make this, your magazine, the best that it can be? I look forward to hearing from you regarding your feedback and opinions.

Until the next issue…

73 de Joe, N6CL

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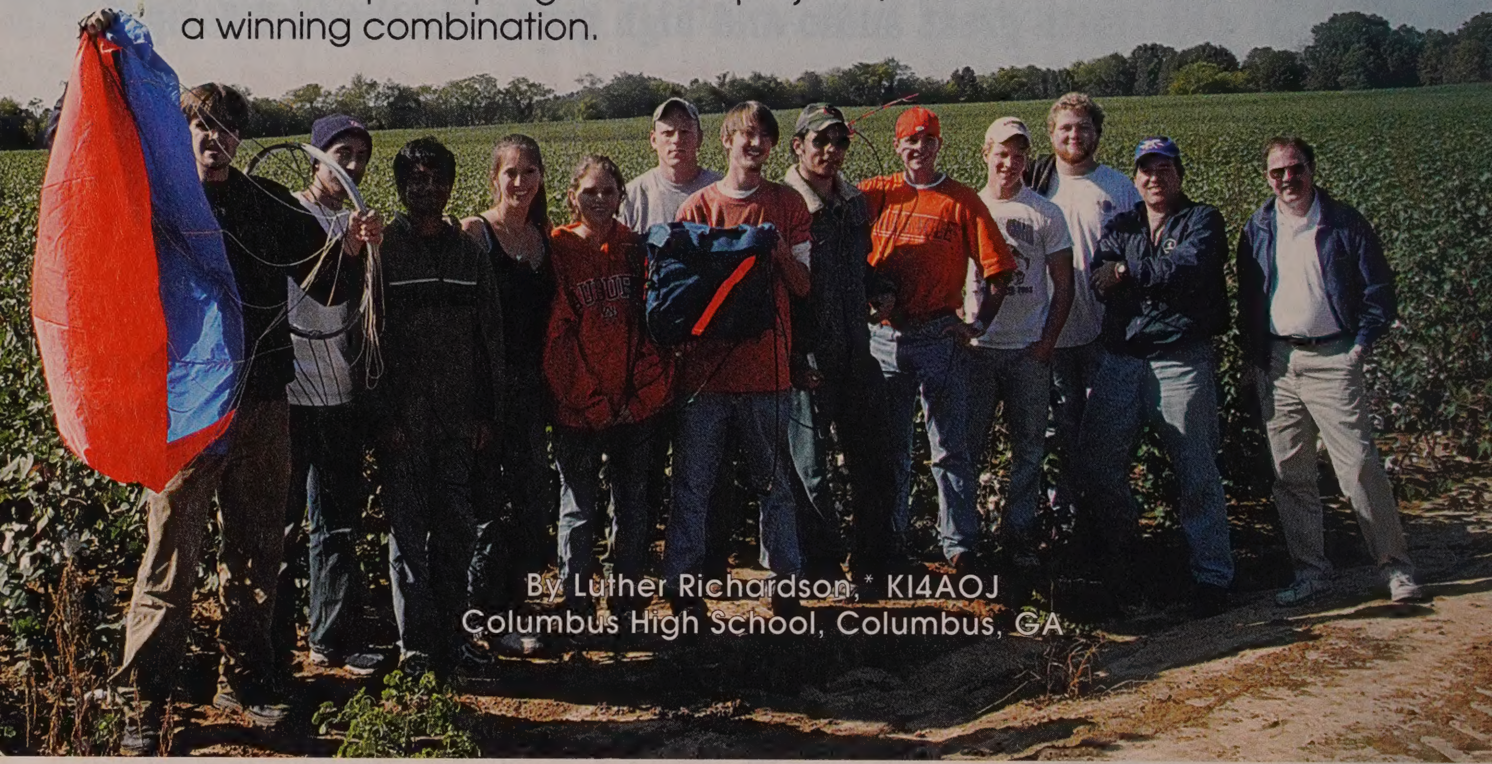
Creating a Few Scientists and Engineers with Amateur Radio

Students, space programs and projects, and amateur radio . . . a winning combination.



By Luther Richardson,* KI4AOJ
Columbus High School, Columbus, GA

The Auburn University balloon recovery team with the author and Keith Warren, AK4KO, on the far right. The launch site was selected to aim for the only flat terrain in the southeast, farm land and specifically a cotton field. (All images courtesy of the author)

If you visit an undergraduate physics or engineering lab at any college in the country, you will be alarmed to find out how many students have never built anything mechanical or electrical during their experiences in or outside of their classes in high school and college. Can the amateur radio community make a difference in the quality of educational opportunities available? Is it worth doing? These are the questions addressed in this article. Students at Auburn University and at Columbus High School (CHS) have completed some projects using amateur radio that do amazing things. For many science and engineering students, the lessons learned in these kinds of projects usually are transferable to an actual job setting.

Students who take on these kinds of projects often have to learn technical skills along the way, and just as important, they learn project management skills. The key element for both a mentor and organizer is to set up the students for success. The students may fail repeatedly through the various steps of a project and stop trying if they experience the fear of failure. Therefore, gentle nudges and words of encouragement are required, mixed with a few proverbial "kicks in the pants" to keep them going. Access to a knowledgeable amateur radio operator will prevent the students from constantly reinventing the wheel and give them a way out of those "technical dead-ends" that often stop the beginner in advanced projects.

This article describes a university student-built satellite project using amateur radio bands, a high school student antenna experiment that flew on a NASA rocket, and a high school high-altitude balloon program that will fly middle school experiments and use APRS to track the balloon. In the descriptions of these student projects, input by amateur radio operators will be highlighted. In the end, I hope I can convince you that teenagers and young adults really can do interesting things given the right atmosphere for learning, such as the one that exists in the applications of amateur radio.

Some Background

In 2001, I started working with some of my high school physics students at Columbus (Georgia) High School on experiments proposed to NASA and others. The group calls itself the Columbus High School Space Program. In the last six years, this group of students has had over two-dozen proposals accepted by NASA, by the Lemelson-MIT Foundation, by Auburn University, and by others to design, build, and perform original experiments. Most of those experiments have been sent into space or to the very edge of it.

As a graduate student in physics, I have also been a part of the Auburn University Student Space Program *(also see the "VHF Plus" column in the August issue of CQ magazine)*. As you might imagine, the Columbus High School and Auburn University programs have frequently

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e-mail: <lrich@physics.auburn.edu>*

crossed paths. Working with these students typically occurred after normal class hours and became my primary hobby. The reward has been seeing the students succeed. Also, it was kind of nice to see our work ride into space aboard NASA balloons, rockets, space shuttles, as well as spend many months aboard the International Space Station. While space is an exciting destination, it is equally rewarding to work with students and see their experiments dropped from NASA drop towers, and riding the NASA Weightless Wonder (or its more common name, the Vomit Comet).

Regrettably, all of the NASA-sponsored programs in which we have participated in the last few years have now been dropped because of budget cuts associated with NASA's "return to the Moon" effort and lack of funding from Congress to maintain the education component within NASA. However, the NASA Space Grant Consortium still supports a variety of student programs. Also, there are some great university programs and funding sources that can help support student amateur radio projects (see Table 1 for some examples). First, I'll give the background on the amateur radio satellite program called CubeSat; it was the Auburn University CubeSat program that led to the first student amateur radio experiment at CHS.

NASA Space Grant Consortium: <http://www.spacegrant.org/info/who.html>. Most states are represented. Contact the group with an idea to see if it could fit in with their goals.

Best Buy Teach Award & Community Grant: <http://communications.bestbuy.com/communityrelations/teach.asp>. At this website is an announcement about a series of gift-card or spending accounts awarded annually by Best Buy to support a "fun and exciting" education program. Submission for next year's awards must be between July 1 and September 30.

Lemelson-MIT InvenTeam Invention Grant: <http://web.mit.edu/inventeams/>. This is a great one. Students propose an idea for an invention, and selected schools receive up to $10,000 to build it and bring it to the campus of Massachusetts Institute of Technology. We built a vibration-sensitive robot that used amateur radio to send telemetry to a ground station.

One could spend hours searching online through available grants. Most want a teacher to be the primary contact, but good ideas make it hard for the grant providers to say no.

Table 1. Examples of grant sources for space education projects.

CubeSats: Satellites for Science & Engineering Education

It is rare to find a university educator who is driven to do all the work necessary to bring real experiences to students. Dr. J. M. Wersinger is one of those people. In 2002, Dr. Wersinger, a physicist at Auburn University, started a program for students called the Auburn University Student Space Program. One of the main initial goals was to build a student satellite using a predetermined form factor through an international program called CubeSat. The CubeSat program started at the California Polytechnic State University, San Luis Obispo and Stanford University's Space Systems Development Lab.

These satellites must have a mass below 1.0 kg and an external structure in the shape of a 10-cm cube. Several of these CubeSats are in space right now. The CubeSats use amateur radio frequencies to communicate with the ground stations as an agreed-upon rule to involve as many people as possible, thus making education outreach a real possibility for each mission.

The CubeSat effort has spread to over 40 schools in 26 states. A list of schools involved and information about the program can be found at the program website (http://cubesat.atl.calpoly.edu/). A typical CubeSat may cost between $5,000 and $10,000 using off-the-shelf components. The cost for final preparations and launch is another $50,000.

Until now, the only way to get a CubeSat into space has been to buy space on Russian rockets (converted ICBMs, or intercontinental ballistic missles) to ride up as a secondary payload. The launch cost may come down with new launch opportunities for secondary payloads through the private launch provider called Space-X (http://www.spacex.com/) and work to integrate the P-pod (the CubeSat launcher) on American Atlas rockets.

What about the possibility of starting additional programs? An interested and motivated amateur radio operator could contact a pre-existing program to get involved, or maybe even help get one started at the local high school or college.

The original Auburn mission was to be a picosatellite with no attitude control that was capable of maintaining consistent communication with the ground while tumbling. Maintaining ground contact was to be done using a series of antennas and algorithms monitoring and controlling an antenna switching mechanism to maximize communication with ground stations. To test this mission concept, antenna testing began.

With the help of Auburn alumnus and electrical engineer Keith Warren, AK4KO, the student group designed a patch antenna tuned to 1270 MHz. This frequency was selected to be used as the uplink, because it would see less traffic than 2 meters or 70 cm. The plan was to embed a 70-cm twisted dipole for downlink underneath the patch antenna on each face of the cube.

CHS Program subSEM 2: Testing Communications with a Tumbling Satellite

Because I was involved in the CubeSat project while teaching full time at Columbus High School (CHS), I gave the Auburn University satellite-design review

This is a picture of the CalPoly CubeSat CP-4 being deployed in space. It was taken from the Aerospace Corp. Aero-Cube-2 CubeSat. The image was stored and sent down using 902– 928 MHz at 9600 bps, GFSK, 2 watts of power.

CHS students working in a cleanroom to create a patch antenna to be flown into space. From left to right: Gily Raz, Matt Lord, and Brianna Veenstra.

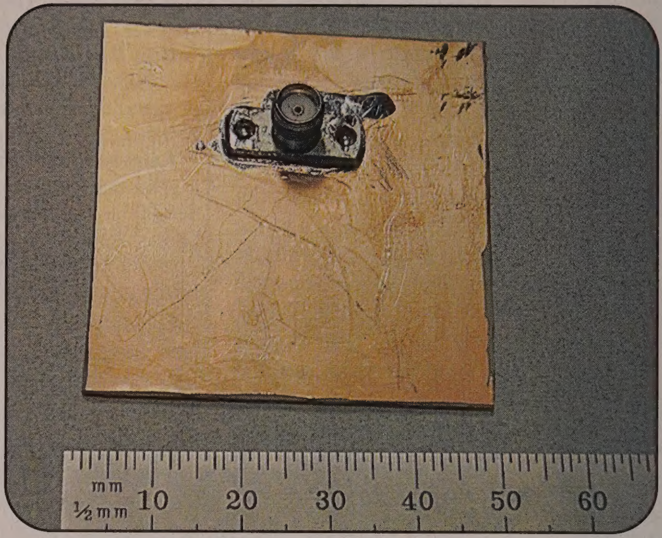
documents to the high school students to help them think of ideas for experiments to fly on a NASA rocket. NASA sponsored an annual competition called subSEM (suborbital Student Experiment Module), which used to be part of the Education Program at Wallops Flight Facility before budget cuts eliminated the program in 2006.

The students very quickly saw that the antennas were the experimental part of the Auburn effort, and they began writing the proposal. They were looking for a slot to ride to space on an Orion suborbital rocket that would climb up to 160,000 feet while spinning at four revolutions per second.

NASA selects only four high school experiments a year to fly into space on their sub-orbital rockets, with only one chosen from the southeast. In the years 2003, 2004, 2005, and 2006, the representative high school from the southeast was Columbus High School. This student proposal was the first CHS Space Program selected experiment to fly on a rocket, and it flew in the summer of 2004.

The students proposed to fly a patch antenna to measure its ability to capture packet radio transmissions from the ground. They ended up making the antenna in an Auburn University clean room. The antenna was to fly on board the spinning rocket with the antenna centered in a small 1.5-inch quartz window and monitor 1265 MHz using a Kenwood TH-59 radio. (This same type of antenna also flew on an Auburn University balloon to 93,000 feet and sent telemetry to a ground station 50 miles away.)

The TH-59, which is a single-band 1.2-GHz radio, had its speaker output connected to a signal conditioning circuit that was connected to an MP3 player. The MP3 player was to record audio of whatever the TH-59 was able to uplink from the student-run ground station.



Final picture of the antenna, tuned to 1.265 GHz, with an SMA connector.

On the ground, the students used a 1.2-GHz Yagi antenna connected to a Kenwood TM-541A and a Kantronics KPC3+ TNC connected to a laptop computer running TeraTerm. They manually tracked the rocket using timing marks on two protractors that were determined by doing a little physics using the known launch parameters of the rocket.

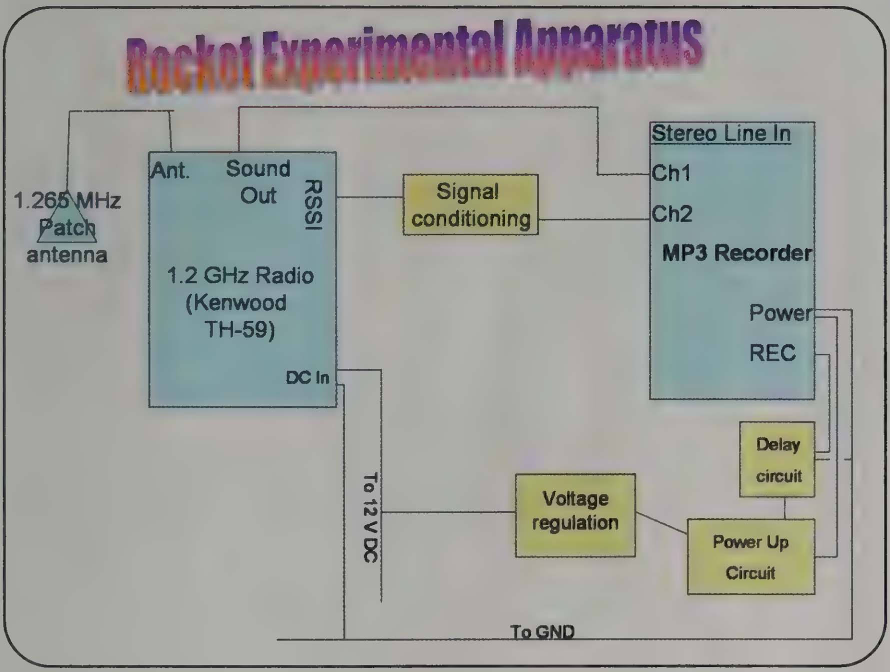
The original proposal also had a downlink experiment, but NASA was a little nervous about this because there was an outside possibility that our 70-cm downlink would resonate with the frequency they use to self-destruct the rocket.

The laptop ran the TeraTerm program and sent a sequence of letters. This sequence was comprised of three letters and symbols so that each three-letter combination represented a three-digit base94 number (using everything available on a standard keyboard). The experimental plan was to play back the MP3 recording of the packets to see which packets made it to the experimental antenna, and the three-digit base94 number meant they could tell when in time each packet was sent.

Four students and I went to Virginia to work for a week so we could integrate our satellite into the overall launch program and be part of the experiment at the actual launch in June 2004. The launch was scheduled for sunrise. Prior to the launch we had to set up. The team arrived at 3 AM and began setting up the laptop, TNC, radio, and antenna on its PVC pole.

Finally, at 6:30 AM the countdown began. We were only a few hundred yards from the rocket, so the incredible noise of the launch made it a challenge to track the rocket and follow the experiment procedure. The student team tracked the rocket for almost 30 minutes until we actually heard the lower stage impact the ocean 30 miles away. NASA had a boat crew in position to recover the payload section, which was floating gently back to Earth by parachute.

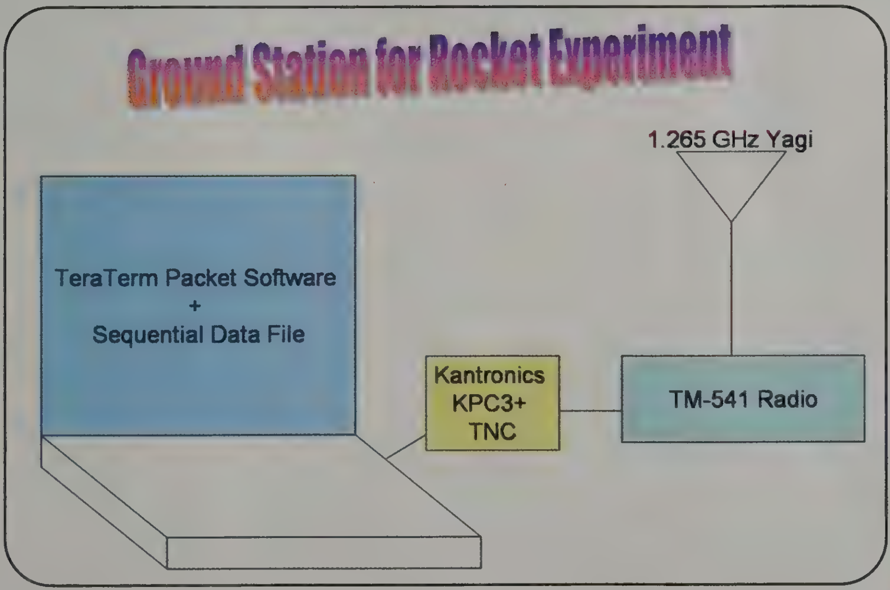
Later that afternoon, the students eagerly helped disassemble the rocket and took their experiment to their workstation. On the lab bench, the MP3 player was manually turned on and the students attempted to play back the data. No file was recorded. No data had been collected. It was heartbreaking for them, and tears were shed.



System block diagram for the student antenna experiment sent to space on the NASA Orion suborbital rocket.

By design the MP3 player had been stripped of its case so it could be turned on and its record buttons activated by an electronic timing circuit that engaged when power from the rocket was applied about ten minutes before launch. In shipping, the ground wire had come loose from the MP3 player. The wire was soldered back in place before integration to what appeared to be a solder remnant on the MP3. When the experiment was tested by the students on the lab bench while at NASA, it recorded fine. Apparently, the solder point was not a true ground, so when the experiment deck was mounted in the rocket, the ground changed, which caused the MP3 player never to turn on and record.

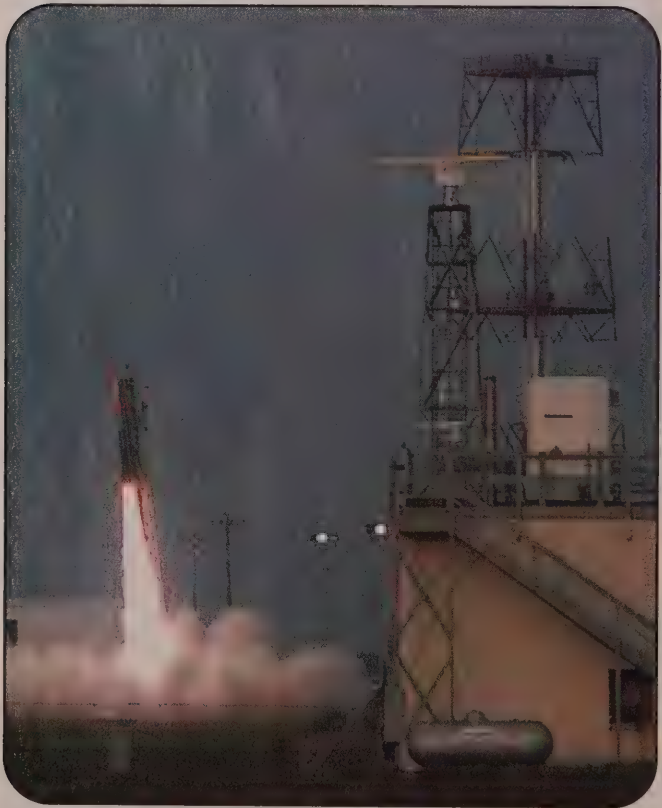
Even so, post analysis showed something interesting about the power consumption by our experiment deck. A very small periodic surge in current was pre-



System block diagram for the ground station that sent text packets to the student antenna experiment on the NASA Orion suborbital rocket.

Experiment in action. The Yagi is pointed at the rocket high in the sky 10 seconds after a thunderous launch. The students who were tracking it were so disciplined that they never looked up to see the rocket launch, even though they were only 300 yards away.

sent on top of the constant current draw used by the idle radio. The TH-59 had been modified so a voltage could be measured across its internal relative-signal-strength indicator (RSSI). It took many hours of help from Keith, AK4KO, and the help of the TH-59 service manual to get this to work correctly. In the middle of the rocket flight, the observed voltage surges appeared four times per second—the same as the rate of rotation of the rocket. It was possible that the antenna was working well enough to use a bit more current when it was seeing



Launch of the NASA Orion suborbital rocket carrying the student experiment.

Kelts Green, Gily Raz, Matt Lord, and Brianna Veenstra (from left to right) perform final testing on their antenna experiment before integrating the experiment plate into the NASA Orion suborbital rocket.

Matt Lord, the author, Kelts Green, and Gily Raz (all in the foreground) set up the ground station for testing in a NASA lab at Wallops Island Flight Facility.

the signal from the ground station, causing a short spike in the RSSI meter.

The road to complete this experiment was a long one, with many trips to Auburn University to use its clean room and anechoic chamber to build and test the antenna. This experiment took over nine months for the students to complete, and they took away a hard but valuable lesson on the importance of attention to detail in science and engineering. From this particular group, two of the students went on to attend the Massachusetts Institute of Technology.

Taking Students to the Top of the Atmosphere with Amateur Radio

As the readers of *CQ VHF* magazine saw in the Spring 2007 issue *(see the article "Through the Back Door," by Kevin Carr, KE7KVT)*, it is possible to send amateur radio gear to the very

A CHS student team with the rocket payload section after recovery from the Atlantic Ocean. Notice the stripped paint from air friction and heating during the rapid ascent through the atmosphere with acceleration up to 17g's.

edge of space. In the summer of 2003 I traveled to the University of Colorado at Boulder to attend Chris Kohler's first "Starting Student Space Hardware Programs: A How To Workshop" (http://spacegrant.colorado.edu/studentsat/). This is the same workshop that KE7KVT wrote about in his article. Dozens and dozens of balloon programs have been started by those attending these workshops. We learned from the Edge of Space Science (http://www.eoss.org); the High Altitude Balloon Experiments in Technology (HABET) associated with Iowa State University (http://cosmos.ssol.iastate.edu/HABET/Home.html); and the Balloon Outreach, Research, Exploration and Landscape Imaging System (BOREALIS) from Montana State University (http://spacegrant.montana.edu/borealis/) how amateur radio can allow one to do science at the very edge of space.

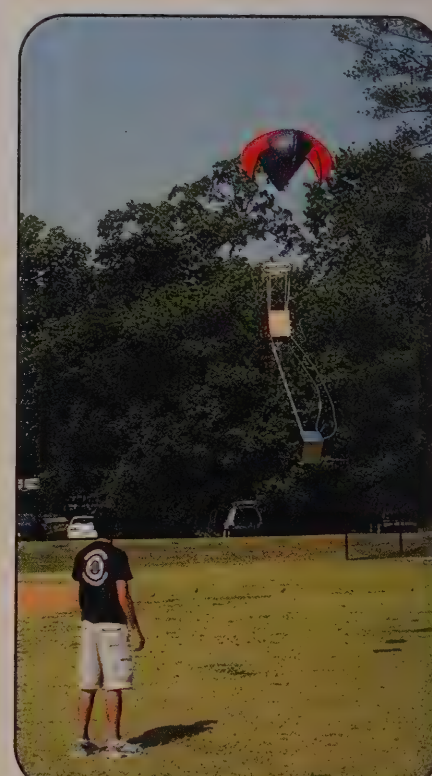
These 8-foot diameter balloons, typically filled with helium, can provide upwards of 20 pounds of lift to carry about 12 pounds of payload to the top of the substantive atmosphere. Just like a boat floats on water, these balloons try to float on top of the atmosphere at around 90- to 100-thousand feet—that is, until they stretch to several dozens of feet across and then burst. Hopefully, a parachute will slow the fall. The trip typically takes about 90 minutes.

The FAA has regulations and guidelines for unmanned free balloons. However, those regulations are less intense if you stay under 12 pounds in at least two different structures. For more information on the regulations see <http://www.chem.hawaii.edu/uham/part101.html>.

When I returned from this summer workshop, I told my fellow members of the Auburn University Student Space Program what I had learned. With some motivation fueled by the excitement of sending our work to space, and with the help of the Auburn University Amateur Radio Club, we launched our first balloon four months later. This was not just a simple APRS beacon either. The first Auburn balloon carried with it solar-cell experiments for the satellite project, a patch-antenna experiment related to the rocket experiment previously discussed, an Alnico HT serving as a beacon and repeater, and a digital camera.

Since November of 2002, Auburn University has launched many balloons and has flown several Columbus High Space

Calculator (TI-83) collecting data from a Vernier Data Interface connected to an analog 3-axis Honeywell magnetometer (HMC2300).



Columbus High School student tests the parachute and cutdown system for the Columbus NASA Connections DREAM sky and payload systems.

Program experiments. Now the CHS Space Program has started its own balloon program.

DREAMS

I used some grant money to start a program called Columbus NASA Connections (http://connect.columbus2space.org), which is sponsoring the Doing Research at Extreme Altitudes by Muscogee County (Georgia) Students (DREAMS) program. The idea is that students from across a large school district will engage in a variety of activities related to NASA in the areas of science, technology, engineering, and mathematics. The activities will increase in intensity until they culminate with groups of students designing their own experiments to fly on the DREAMS high-altitude science platform. DREAMS 1, the first mission to fly, will be released later this summer. Some students have been working for almost a year on the DREAMS project, and as of this writing have nearly completed the design.

Help from two amateur radio operators in particular has made this education opportunity possible for over 33,000 students. They are Keith Warren, AK4KO, and John Klingelhoeffer, WB4LNM. Keith is an electrical engineering independent contractor specializing in Micro-Electro-Mechanical Systems (MEMS) technology and has over a dozen patents to his name. John is a retired president and general manager of the communication satellite company COMSAT. He has built satellite components on his own for Bob Bruninga, WB4APR, at the U.S. Naval Academy. Both Keith and John are Auburn University alumni, thus strengthening the connection between the high school and university programs.

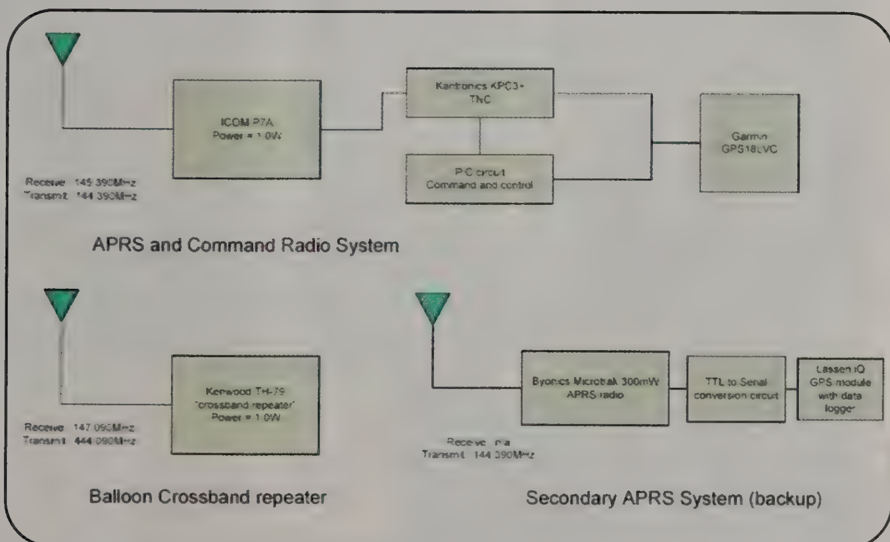
After many visits, e-mails, and hours on the radio and on the phone, the DREAMS design has been formed as shown in the system block diagrams. The balloon structure is comprised of two 9" × 9" × 11" tall boxes made of two carbon-carbon sheets sandwiched between a layer of 1/4-inch Nomex™. The boxes themselves are covered with a Mylar™ film to reflect thermal radiation in the near-space conditions.

Because the temperature is very low at high altitude, there are not many of those slow-moving cold-air molecules to carry away heat built up from absorbed infrared solar radiation. Inside the uppermost box is a very small HT made by ICOM—the P7A model with a mass under 150 grams.

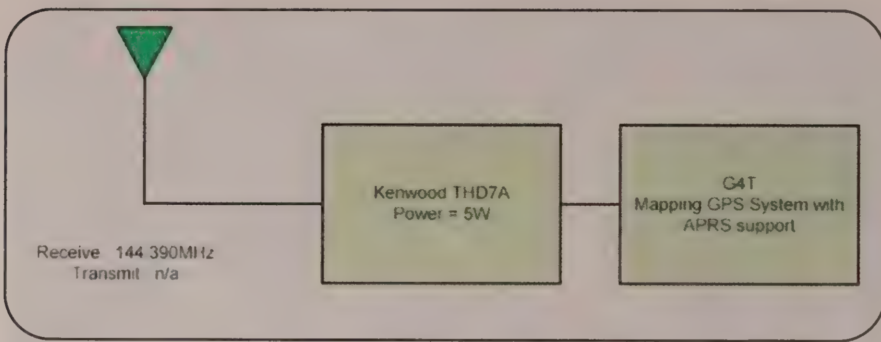
A group of teachers from the Muscogee County School District. These teachers trained to use a retired deep space networkradio dish to do radio astronomy with their classes over the internet (in a program called GAVRT, Golden Apple Valley Radio Telescope).

It is connected to a custom-built vertical dipole, which is integrated into the ring that separates the ropes going from the structure boxes to the parachute. A Kantronics KPC3+ TNC acts as the radio modem, and a programmed PIC circuit listens for one of up to four commands to activate relays if certain text commands are detected. Those commands include a cutdown to apply 12 volts and about 1 amp to a piece of Nichrome™ wire wrapped around the rope that connects the parachute to the balloon. The wire turns bright orange and will burn through the rope in about one second.

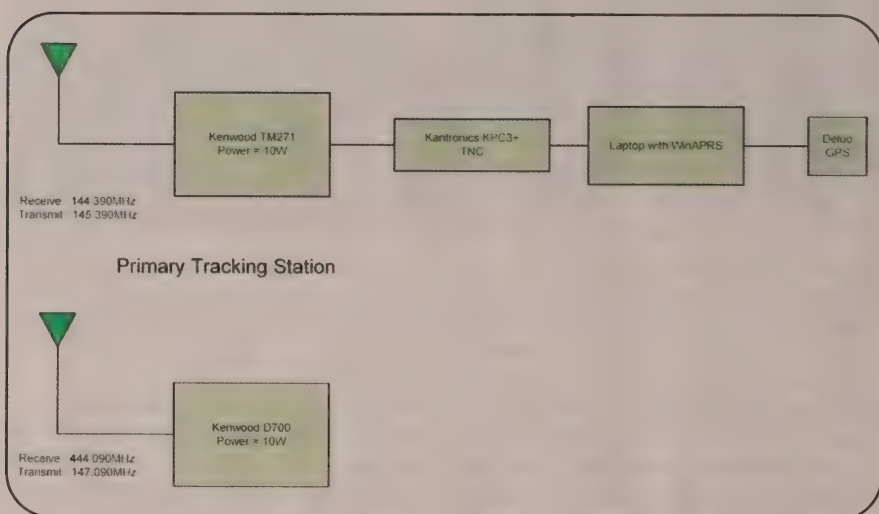
Another command activates a sound beacon (a car alarm) to help find the balloon once it lands on the ground. The PIC



Block diagram showing the Sky Station System that is completely housed in the DREAMS balloon. It facilitates APRS and communication with the ground.



Block diagram of the Secondary Tracking Station. This system is designed for simplicity so that an amateur radio operator could jump on a school bus full of participating students and track a balloon. The system includes a Kenwood handheld with built-in TNC and an APRS-compatible mapping GPS.



Block diagram of the Primary Ground Station System or the Primary Chase Vehicle. This system includes the capability to send command packets to the balloon Sky System to perform various functions and also to use the balloon as a repeater for the balloon chase teams.

Wireless Dynamics Sensor: Three-axis accelerometer, pressure sensors, force sensor. This sensor can be programmed to store data internally at various rates. Programming and data download are accomplished using Bluetooth® wireless technology. <http://www.vernier.com/>; $250

HMC-2300 Honeywell 3-axis magnetometer: This magnetometer is more sensitive than the magnetic compass sensors, and can measure decreases in the magnitude of the Earth's magnetic due to changing altitudes (moving away from the core of the Earth). <http://www.ssec.honeywell.com/magnetic/magnetometers.html>; $199

MMA7260Q Freescale 3-axis Accelerometer: This is a 3-axis accelerometer on an evaluation board ready for analog output. <http://www.SparkFun.com>; $40 (They have many other sensors and products as well.)

Surplus Motorola Pressure Sensor: Item #G15473. <http://www.goldmine-elec-products.com/>; $0.79

Hobo RH/Temp/2x External Logger: This small, self-contained unit is very simple to program and has built-in temperature and relative-humidity sensors and two channels to add more sensor data. <http://www.onsetcomp.com/>; $130

Onset TattleTale TT8v2 Data Logger: This unit allows up to eight channels of data to be recorded at decent rates with 12-bit resolution. Available from Onset Computer Corp. <http://www.onsetcomp.com/>; $500

Table 2. Sensors and data loggers. The sensor/logger is listed, followed by a description, availability information, and price.

circuit is also capable of activating the relays based on input from the GPS. For instance, if the balloon crosses a certain latitude, such as the one close to the airspace of Atlanta's Hartsfield International Airport, the cutdown would be activated automatically in case contact is somehow lost with the ground.

The second box is reserved for the scientific payload, which consists of various sensors and a data logger plus any biological samples. The data logger currently flying is a 19-channel 12-bit Tattletale data logger (http://www.onsetcomp.com/). Some of the sensors that can be flown are detailed in Table 2.

Middle school students in DREAMS must learn about the environmental conditions that occur at 100,000 feet. Then they must come up with a simple research question that can be answered with the kind of data we collect. The student groups do research and complete a report to explain their hypotheses prior to flight. With some training on analyzing data from the sensors using Microsoft® Excel (readily available on most computers), the students get their data after the flight and complete the report by trying to answer their research question.

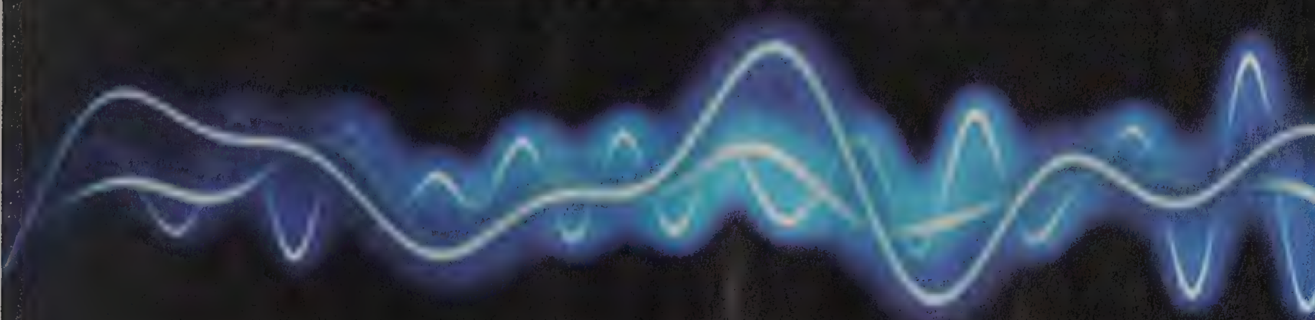
Some advanced high schools or even middle schools can design their own experiment hardware. However, it is hard to find a high school with the right faculty in terms of both technical skill and motivation to support this kind of development. Nevertheless, the DREAMS model can be supported minimally by teachers at any level, with some specific training of those students over the summer and at some weekend meetings during the year. Results of the DREAMS program and more information can be found at <http://dreams.columbus2space.org>.

Summary

Amateur radio has impacted the lives of the students involved in the experiences described here. It clearly takes a lot of time by the amateur radio operators involved, but the payoff is seeing the new appreciation by these students in the application of science, technology, engineering, and mathematics. These are the kinds of things many readers, including this author, dreamed of doing when they were in high school—and this program reaches into middle schools and elementary schools. Amateur radio is making these dreams a reality for some of the next generation. ■

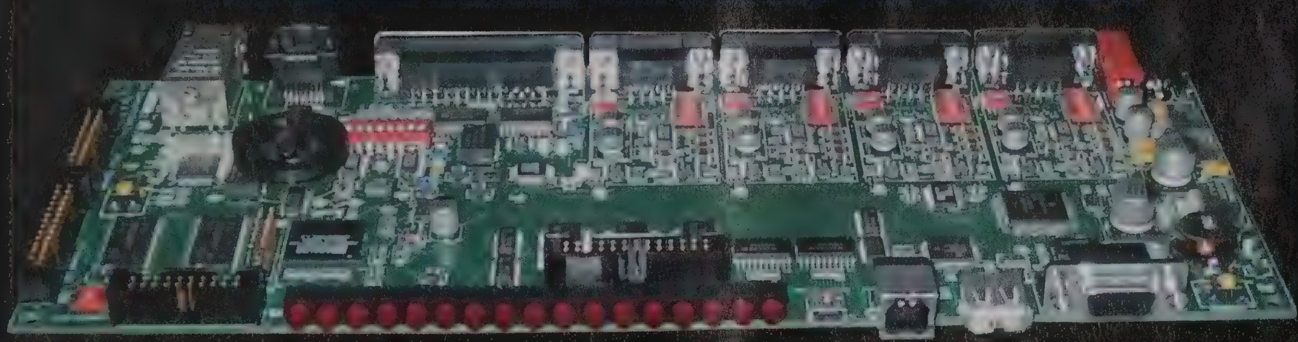
Redefining the Repeater Controller

Introducing the RLC-DSP404 Digital RLC Controller



Link Communications is once again redefining the Repeater Controller. Built upon the time-tested RLC core, this new controller is completely digital and has an unmatchable feature set.

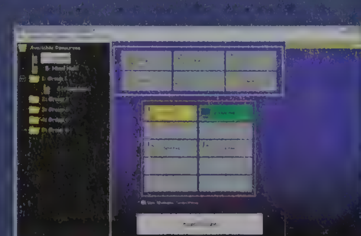
Digital Audio Path
Built-in Ethernet
Streaming VoIP
Remote Control Functionality
Expandable Digital Voice Library
Supports up to 12 Radio Ports
Site Telemetry I/O Lines



Technical Specifications

Radio Ports	4 Radio Ports (expandable to 12) with DB-9 connectors. Individual front panel LED's per port
Radio Port Signals	COR, CTCSS, (1) Audio Input, (2) Audio Output, RS-232. Discriminator and Speaker audio
Telemetry Port	7 Analog Inputs, 0-15V, 12 bit with temperature sensor switch, 8 Input Lines, 8 Output Lines
Time of Day Clock Option	WWVB Receiver serial port supporting the WWVB-404 optional receiver allows off-air time RX
Network/Connectivity	RS-232, 10/100 Ethernet Control Ports, USB Host, USB Slave and USB On-The-Goto (OTG) port
LED Display Feature	COR, CTCSS, DTMF/Tone, PTT display for each radio port. LCD Display optional (Contact Link)
Switch Features	RX gain, TX gain, CTCSS/Tone control, Pre/De-emphasis controls, COR and CTCSS pull up/dn
Other Features	Integrated audio delay, electronic soft-pot adjusters, Digital voice and message recorder, etc...

Repeater and Linking has never experienced such an advanced product as the RLC-DSP404. With its total local and network management, streaming VoIP and powerful 600 MIPS Digital Signal Processor (DSP), the RLC-DSP404 will transform your repeater system into a more versatile and efficient digital system that will change and adapt as repeater systems evolve.



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The Lost Letters of KH6UK

Part 1 – The International Geophysical Year and the Most Well-Known QSO

This two-part article presents the history of Tommy Thomas, KH6UK, as well as excerpts from Walt Morrison, W2CXY's files pertaining to Tommy's ground-breaking QSO with John Chambers, W6NLZ. Part 2, to be published in the next issue of *CQ VHF* magazine, will cover Tommy's pioneer EME work.

By Mark Morrison,* WA2VVA

Ralph "Tommy" Thomas was an accomplished radio operator whose "can do" attitude and excellent operating skills brought notable success on more than one occasion. We begin this two-part article with an introduction covering some of the history of Tommy's accomplishments.

Introduction

First in 1926 (as 2UK) Tommy exchanged messages with the George Miller Dyott expedition in the jungles of Brazil when commercial operators had failed to get through. *The New York Times* even reported on the event in its December 28, 1926 edition. Figure 1 is the front side of Tommy's QSL card.

In 1938, he was one of three radio amateurs to provide weather reports to aviator Howard Hughes on his record-setting flight around the world. In 1953, Tommy provided reports to George Rose, K2AH, during the first use of a transistor in amateur radio. In 1954, Tommy and Paul Wilson, W4HHK, were credited with the first meteor-scatter QSO ever made on 144 MHz. However, as impressive as these feats were, none won the acclaim that Tommy's 1957 QSO with John Chambers, W6NLZ, did, which is arguably the greatest amateur achievement of the International Geophysical Year (IGY). Some may think this accomplishment had nothing to do with the scientific purpose of the IGY, but in 1960 the General Electric company awarded both Tommy and John the prestigious Edison Award, the only time it was ever awarded for *scientific* achievement.[1] The judges of this award are said to have compared this accomplishment with the first radio transmissions across the Atlantic in the early 1900s. Even today this event remains a hallmark of amateur cooperation, skill, and determination.

Tommy lived in New Brunswick, New Jersey, where he worked for RCA Communications (RCAC), formerly Marconi America. In 1955, RCAC relocated Tommy to Hawaii to be engineer-in-charge of its Trans-Pacific radio station at Kahuku, Oahu. This historic station was one of the original Marconi stations spanning the globe in 1914, completing the link between Japan and California.

Once settled in Hawaii, Tommy received a new callsign, KH6UK, and put together his beautiful station (Photo A). Note the greetings on the right side of the photo. To keep in touch with his friends back home, Tommy wrote or typed letters, including many to my father, Walt Morrison, W2CXY. The typewriter used for many of those letters can be seen in the photo. When Walt passed away in 2002, these letters were discovered in a basement filing cabinet; they hadn't been seen in nearly 50 years!

Although much has been written about that historic QSO of the IGY, very little information has been added since. With the 50th anniversary of this event in July and Tommy's lost letters to guide us, what better way to celebrate than through the words of Tommy himself? Here, then, is the untold story of the most famous QSO of the IGY.

The Untold Story

By April of 1956, Tommy and Helyne Thomas had settled into their new home in Hawaii. It took about a year to get the

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e-mail: <mark1home@aol.com>

Some Background

It was in 2002 that Walter Morrison, W2CXY, became a Silent Key. Outside of his family, his passing was hardly noticed, except by a few close friends. One member of his family, his son Mark, followed in his father's footsteps in the hobby of amateur radio and became licensed as WA2VVA.

One day after his father's passing, Mark decided to go through his father's filing cabinet, which had been stored in the basement for lack of a better place to keep it. Tucked away in that basement filing cabinet Mark found some handwritten letters and other ham radio related memorabilia not seen for nearly 50 years.

The author's name on the letters was unfamiliar to Mark. However, Mark's brother Walter recognized the name as someone who once worked for RCA Communications. Written to W2CXY by VHF radio pioneer Ralph "Tommy" Thomas, W2UK/KH6UK, these letters provide a behind-the-scenes look at amateur VHF radio during the 1950s, not just from the perspective of those who lived it, but when they were actually living it! Those letters, in addition to numerous audio recordings, vintage QSL cards, and clippings from various ham radio magazines offer invaluable documentation to what was perhaps the most important QSO of the International Geophysical Year, as well as much more about the pioneer VHF plus operators of Walt's day.

What follows in this two-part article are excerpts from W2CXY's files pertaining to Tommy Thomas' ground-breaking QSO with John Chambers, W6NLZ. Part 2, to be published in the next issue of *CQ VHF* magazine will cover Tommy's pioneer EME work.

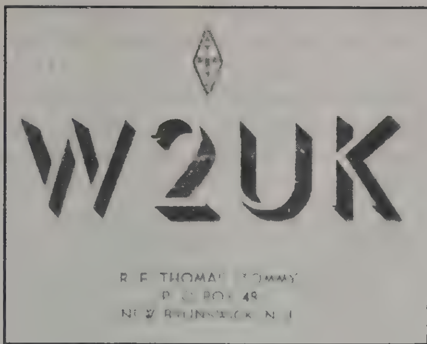

Figure 1. Tommy's QSL card when he was W2UK in New Brunswick, NJ.

house in shape, including patching a leaky roof and replacing window panes etched by years of salt air, but once that was done, they were quite happy. Located on the north shore of Oahu, their house was close to the RCAC facility and it was a short walk to the beach.

Tommy had his own radio room, situated just off the lanai, with large glass doors that opened to fresh air and the sights of Hawaii. Although an operator's dream, its proximity to the high-power transmitters of the RCAC station made for terrible interference, especially on 6 meters and the lower frequency TV stations out of Honolulu. Nonetheless, the location had a relatively good shot to the West Coast, thanks to Marconi engineers who had surveyed the spot several years earlier.

Tommy's first project was to build a VHF array for 144 MHz. At the time, the greatest distance spanned on 2 meters was about 1100 miles, and since the nearest place with any significant 2-meter activity was California, some 2500 miles distant, Tommy was none too optimistic about the DX possibilities. In a letter to Walt, he said it this way:

> As far as 2 meter operation is concerned, out here on the island there's not a great deal of it. There's some CD work and attempts to work island to island but necessarily so I suppose, if you can't work anywhere else then why even try. Just about the closest place you could expect any activity is the West Coast and that's 2500 or 3000 miles away. So I suppose that has a damping effect on the long haul stuff out here.

Tommy's first real challenge was to work the local hams on the other side of the island, near Honolulu. A large mountain stood in the way, but Tommy convinced them that they could work each other, and they did. After that he set his sights on the West Coast.

As with most VHF enthusiasts of the era, Tommy thought a lot about moonbounce, which was only natural considering the lack of other stations within the range of a typical meteor-scatter or sporadic-*E* contact. His letters to Walt, W2CXY, mention the need for "25 dB minimum" and multiple "Long Johns," a name that describes the "long, long Yagis" popularized in *QST* magazine by John Kmosko, W2NLY, and Swan founder Herb Johnson, W6QKI. In one letter Tommy mentioned that Herb and Jim were "set for Moon deal tests around July" and commented to Walt that "they might beat us to the punch!"

By May 1956, Tommy had found someone interested in running 2-meter schedules with him. In his letters to W2CXY he mentioned for the first time that John Chambers, W6NLZ, "might be a good man to have on tests" and that "John wants to attempt 2 meters across the Pacific." Although the distance was about twice that of the best DX of the time, Tommy was ready for serious

weak-signal work. Tommy would later describe his new partner this way: "John is a very fine man to work with. He's always on the ball and I've certainly enjoyed my many contacts with him. He certainly is a VHF man of high caliber and high interest."

By this time Tommy was talking about "Big Bertha" antennas, such as those used by W6QKI and Ed Tilton, W1HDQ. At the time Ed was editor of *QST* magazine's popular VHF column "The World Above 50 Mc" and any recommendations from him would have carried significant weight.

Back on the East Coast, the growing number of high-power VHF stations was causing interference problems for weak-signal operations. A group of amateurs, including W2CXY, petitioned the ARRL to request the FCC to reserve the low end of the 2-meter band exclusively for CW work. Although Tommy didn't have to worry about such interference because of his remote location, his proximity to the RCAC station brought many of the same challenges that faced his friends on the East Coast. As such, he was quite interested in this matter. In a letter to W2CXY, Tommy mentioned that both he and his MARS director were interested in the exclusive CW segment. Tommy also mentioned that sideband splatter on 6 and 2 meters was particularly bad because of station interference. If Tommy were to do any serious DX work on 2 meters, he somehow would have to get around this interference.

By the summer of 1956, Tommy began construction of his VHF array. Work was slow due to the summer heat, but by October the beam was finally in position. Tommy sent Walt pictures to share with his friends back home. Upon seeing the pictures, John, W9WOK, commented that the antenna hardware, including the utility pole, looked quite similar to Tommy's setup in New Brunswick. Photo B shows Tommy on the left monitoring a crew of men ready to hoist the 56-element beam to the top of a 90-foot utility pole. The other men in the picture are "riggers" from RCAC.

Photo C shows the beam in final position. Note that it could be rotated but not elevated, thus ruling out any serious moonbounce work. Tommy later commented to W2CXY that he would replace this with a "first rate job" for moonbounce work, if he had the time. Tommy's stay on the island was supposed to last only three years, and because he was uncertain if RCAC would ask him to stay longer, he hesitated to build something bigger from the start.

In the fall of 1956, Tommy continued to exchange moonbounce ideas with Walt, W2CXY, and confirmed that Jim and Herb had not yet made moonbounce contact. They discussed plans for circularly polarized "monster antennas" and Tommy mentioned interest in contacting Dr. John Kraus, W8JK, regarding his work in this field.

In November 1956, Tommy began 2-meter tests with John. He also started to experiment with 6 meters. In an audio-tape letter he mentioned to Carl Scheideler, W2AZL, his plans for 6 meters this way:

I had hoped, Carl, to make use of that very fine converter you sent me for 6 meters. I had hoped to do some work on 6 in conjunction with the 2 meter experiments, as I thought maybe if I could pick out the periods when 6 was open via sporadic-*E* we might be able to do something on 2 meters at that time. Just might. That, of course, was my intention but it didn't materialize mainly for the reason that the interference is so bad here on 50 Mc from

the station that it's practically impossible to do anything through it.

Tommy wondered what it was like back in New Jersey with all the big 2-meter stations. Still concerned about interference, he asked, "Has anyone figured a way to reduce crosstalk caused by overload in converters?"

The first half of 1957 was a busy one for Tommy. First there was a tidal wave that nearly swamped his shack. He described the ocean as slowly receding before rising slowly up to the level of the dunes, at which point it spilled over and into his yard. They had 18 inches of water all around the house, and if not for the fact that it was low tide, his radio room might have been flooded. Then there were serious manpower shortages at the station, and the lack of qualified workers to fill the openings. There was also a steady stream of visitors to the RCAC station, including several top brass from RCAC. On one occasion, the legendary David Sarnoff visited Tommy's shack and showed a great deal of interest in his meteor-scatter operations.

Tommy kept schedules with John practically every night from May into June of 1957 without success. They even tried daytime meteor-scatter work, but this was abandoned when John reported poor results with other stations with which he had schedules. In a tape sent to W2CXY just weeks prior to the record-breaking QSO, Tommy explained that since John lived in an exclusive neighborhood of Los Angeles (Palos Verdes Estates) and was only using a single Long John, he

Photo A. Tommy, KH6UK's station in Hawaii in 1955. The greeting on the right side of the photo reads: "Walt W2CXY, Aloha, Tommy KH6UK."

Photo B. Tommy (on the left) monitoring a crew of "riggers" from RCAC getting ready to hoist the 56-element beam to the top of a 90-foot untility pole at his location in Hawaii. (Photo circa 1956)

Photo C. The 56-element beam in final position.

On Into February

Hawaii-east coast contacts are ordinary events now judging by your reports. Quite a few of these QSOs took place on February 1st around 1500 EST. W1PHR worked KH6UK and KH6NS, and was hearing W6s at the same time. The Hawaii signals didn't extend much beyond Vermont, however, because W1QCC/VE1 in Pictou, N.S., heard only W6s and W7s at this time. Californians worked KH6s and W1s simultaneously on F2 on February 1st and their nearby neighbors and W7s were coming through on back scatter. Around 1530 PST (still on the 1st) K6RNQ worked ZL4GY in New Zealand. It's the first time that we have come across this particular path on any of your reports. K6RNQ repeated the performance on the 7th when he worked ZL2ABX at 1615 PST.

Figure 3. "The PRP News" article about Tommy's finding a way to get around station interference.

was not too hopeful that a contact would be possible. Tommy put it this way:

> John unfortunately lives in a very exclusive neighborhood and cannot put up a big beam. He has one Long John, which as you well know is not sufficient. We're going to need everything we can get up in the air and also all the power and the best receivers and converters we can get if we're going to do anything at all. Starting out with the limitation of such a small antenna it's almost a forgone conclusion we're not going to get anywhere."

By June of 1957, Tommy must have been thinking the only DX possible from his QTH would be moonbounce, but even that was somewhat of a disappointment.

Photo D. KH6UK's "2×4" moonbounce array poised for testing.

In a tape letter to W2CXY he said:

> I don't have too much time Walt, or too much energy either for that matter, when I do have the time, to build bigger and better antennas for moon reflection work. I'm a little disappointed along those lines but I don't know, weekends come along and when I m not working I'm trying to catch up on a little rest and preparing for the upcoming week. It's been rather rough over here. A lot more work than I had anticipated and a lot less leisure. Whether I will still find time before we return to put up a bigger beam or not I don't know. I'll have to get some energy and ambition from somewhere's if I'm going to do it. I don't seem to have it now. Over here on the islands you get so after a while you're contented to just sit and reflect. In the summer time it's rather warm and not conducive to a lot of occupations and activities that require expenditure of energy. Most people around here just sit!

In the following weeks, however, all that changed. Using techniques that Tommy and Paul, W4HHK, no doubt refined prior to their first 2-meter meteor-scatter QSO, Tommy and John used the HF band for liaison work. Once contact had been established on HF, they regularly switched to 2 meters to see if anything could be heard. They did this night after night until finally, on July 8, 1957 at 6:30 PM Hawaiian Standard Time (HST), Tommy's 2-meter signals were picked up by John Chambers in California. The signals lasted until 7:35 PM HST, at which point W6NLZ left the air. After John confirmed his QSO with Tommy, John's wife, W6NTC, took the controls and also had a QSO with Tommy. Tommy said he then called CQ for the next three hours to see if anyone else would reply, but no one did. He made three reel-to-reel copies of the QSO. One was sent to Ed Tilton, W1HDQ, another to John Chambers, W6NLZ, and the third to Walt Morrison, W2CXY. Here is an excerpt of what Tommy reported on his tape to Walt:

> The recording was fairly good, in spite of the fact that I was so excited I didn't want to change any of the tuning controls and there was quite a bit of overloading at times. Also my signal sounded sad as you probably know by now. The signal sounds much better on a

pair of cans than it does on a loudspeaker. It always does.

We had been running this schedule, as you know, since last November, and I had never even heard a peep of any kind during that time. I had one report from 7, I think it was VVJ, that he copied the letter U out of my call but I could never get him to verify it. So I'm not sure that he actually heard it. Maybe he just thought he did.

This thing came as a complete surprise to us. I was listening on 20, and 144 at the time; it's a usual procedure for me to transmit on 14.095 and 144 Mc. And John would listen to 144 after working me on 14.095 and tell me how conditions were and how long he wanted the schedule. So this started the same as any other. When I said bye after a five minute transmission, John was calling me like mad and gave me a report of 559 I believe it was, on 2 meters. I thought he was suffering from the heat.

But he insisted such was the case so I dashed madly for the 2 meter converter and turned it on and hooked the antenna on it. And lo and behold there he was. The signal was in more or less the whole hour. He was very much excited. So was I! And I believe we would have stayed in much longer if John had wanted to stay on but he was anxious to get off and call up Ed and I was anxious to see how long it would stay in.

The call from W6NTC was a complete surprise also. I thought it was a second station calling. Well I guess it was in a way. And thought possibly it was someone in the same town. When they said Palos Verdes Estates I thought it was somebody with a 522, probably one mile farther than John! And I referred to him as "OM." I guess John's wife felt anything like an OM because she's eight months pregnant. It finally dawned on me what it was all about a little later, after the excitement had subsided. I really didn't know that John's wife was a ham. I don't believe she's active.

The tape is on its way to Tilton. I sent one to John and this is the next one to go off and I guess this will be the last one. It takes quite a while to make them up as you well know and I know that you will circulate it there in the East.

There's quite a bit of interest shown in the results over here in the newspapers and on radio. I just finished listening to a broadcast on ARRL and I see it's on there. So this will give you fellows something to shoot at. Maybe if you'll take time out from ping pong you can see if you can work some stuff. I guess you're doing OK though.

QST reports more and more states in the "states worked column" all the time. I look them over with envy and wonder how I'm ever going to catch up. I guess I never will. I have *one* now! I guess that's it.

Interest in this QSO was a highlight of the 7th U.R.S.I. (Union Radio-Scientifique Internationale) conference held in Colorado that year. Scientists from around the world, who had gathered to discuss radio propagation issues, showed considerable interest in this record achievement.

In the years that followed, Tommy and John continued their schedules, first on 220 Mc, where they found success in July of 1959, and later on 432 Mc, where John could hear Tommy but not the other way around. Tommy also found a way to get around the station interference as the excerpt (Figure 3) from "The PRP News" shows.

Tommy once commented to W2CXY that a new DX record could be established on 6 meters by working South Africa from his location. However, there just wasn't time to do everything, so this plan was abandoned in favor of serious moonbounce work on 144 MHz. Photo D is a picture of Tommy's "2 × 4" moonbounce array poised for testing. The story of Tommy's moonbounce activity will be the subject of Part 2 of this article.

Note

1. The *VHF Manual* 1972.

A Simplified Path to a High-Performance 10-GHz Transverter System

With the increase in popularity of the 10-GHz band, KH6WZ has risen to the challenge and created an X-band transverter that is quick to build.

By Wayne Yoshida,* KH6WZ

The challenge: Get another X-band transverter built quickly for a fellow club member who has been procrastinating for over a year about getting on the 10-GHz band. The solution: Get in there and help him build it!

We wanted to see how quickly a 10-GHz transverter could be built using readily-available components and surplus modules. All we needed were the "ingredients" for the system, some free time to build, some knowledge of how the modules connect together, and a good technical friend with test equipment for the microwave bands. This last ingredient was probably the most important, since the ability to test the unit (as well as surplus parts) requires some specialized gear. Fortunately, I have access to such a resource: my fellow San Bernardino Microwave Society (SBMS) club member, Dave Glawson, WA6CGR. Other microwave-specialty clubs have their cadre

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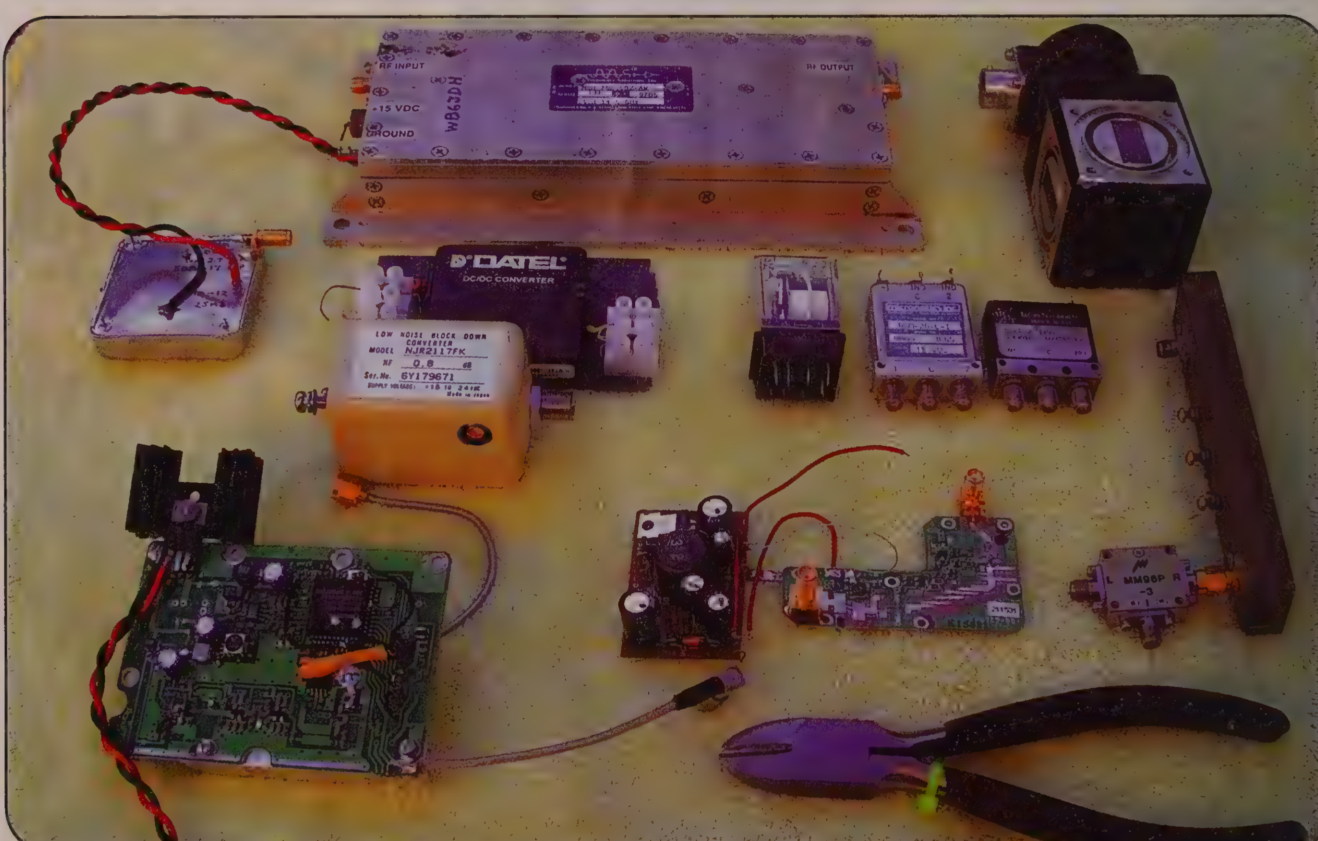

Photo A. Box of ingredients needed to form a complete 10-GHz transverter. Available surplus is changing, and the new challenge is moving from "where to get parts" to "where to find the time to build it." (All photos and artwork by the author)

of experts, and most of them are willing to help others.

The box of parts can be seen in Photo A. This box of ingredients includes a 1-watt, solid-state power amplifier (SSPA), all tuned up and tested for use at 10.368 GHz! The amateur radio X-band scene is changing rapidly, since parts are becoming easier to acquire. The challenge is moving from "where do we get parts?" to "where do we find the time to build a system?"

An enhanced, "competition class" 10-GHz rig would include a receiver preamplifier (low-noise amplifier, or LNA), a 2-foot (or larger) dish antenna, and a power amplifier putting out a full 1 watt (30 dBm) or more. The rig described in this article is just such a unit, with a receiver noise figure of less than 1 dB and about 23 dB conversion gain. Nine-hundred milliwatts at 10368 MHz appears at the antenna port (see Photo B).

Photo B. Surplus material and previously exotic parts such as microwave mixers are easier to obtain these days. This X-Band system has a receiver noise figure of 0.7 dB, with transmit power of 900 mW measured at the antenna port. An 18-inch reflector is attached to the front of the chassis box with machine screws.

It's a New X-Band World

In 1993 Zack Lau, KH6CP (now W1VT), ran a two-part article in *QST* magazine about building a 10-GHz transverter from "scratch."[1,2] Zack's project simplified parts procurement by eliminating surplus "brick" oscillators and exotic surplus, and the bill of materials called for off-the-shelf components.

As mentioned, today's surplus availability has changed radically with online auctions and other resources, including fellow club members with access to some fairly complex components such as waveguide relays and mixers. One of the biggest "boosters" on the 10-GHz ham radio front is the availability of QualComm modules, sub-assemblies, and modification instructions made available to hams. I have seen surplus QualComm units and systems for sale at local swap meets and on the online auctions for very good prices. For example, I recently saw a complete QualComm OmniTRACS® system on eBay with a starting bid of $10. Certain modules in this system are extremely useful for the microwave experimenter.[3] If you are lucky enough to find these useful QualComm units, please remember to heed the warning about not contacting QualComm with any inquiries. You must contact the ham community (San Diego Microwave Group in particular) for information on these units.

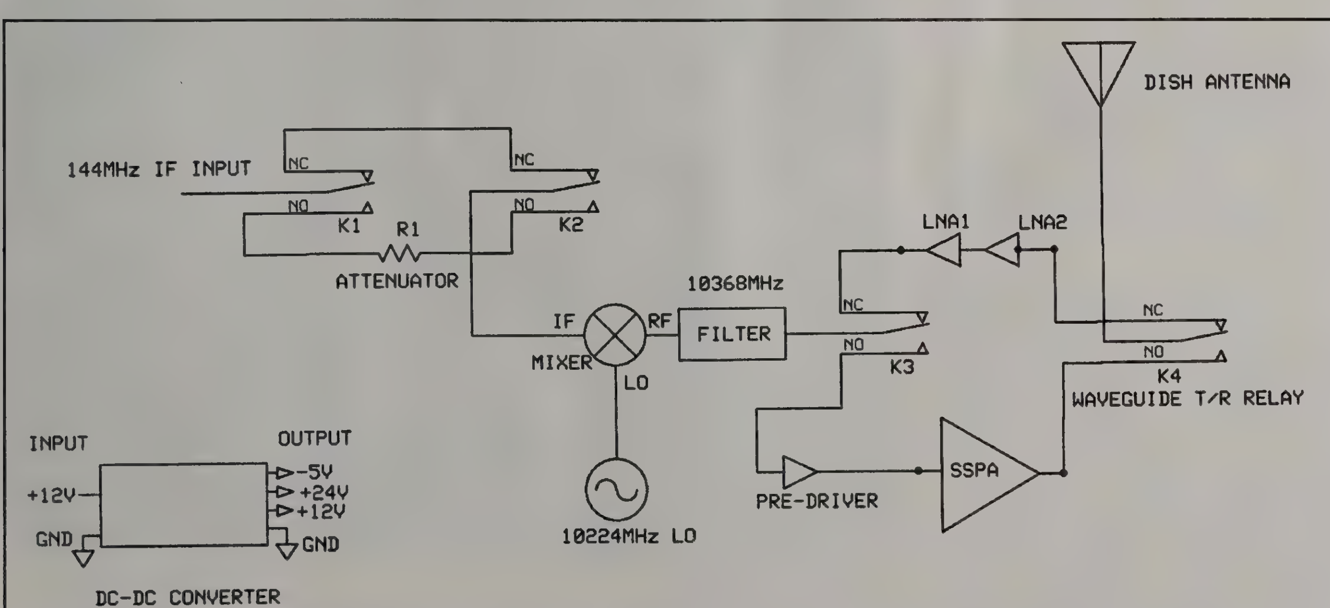

Figure 1. A simplified block diagram of an X-Band transverter using a 144-MHz IF.

Photo C. A surplus DC-DC converter makes minus and plus 12 V as well as 5 V from a single 12 VDC input. The –12V and +12 V outputs are connected together to make 24 V, used to drive the SMA relays.

In addition, commercial microwave companies catering to hams—such as Down East Microwave (DEMI), and the DB6NT units available from Kuhne Electronic and SSB Electronic—provide kits, pre-built transverters, and other useful modules, such as local oscillators, for the microwave bands. These "store-bought" products can greatly simplify the path to successfully getting on the microwave bands with proven designs and technical support.

Building Blocks and Component Notes

Figure 1 is a simplified block diagram of the rig, based on the box of ingredients. Since we are dealing with surplus material, it is best to describe the needed circuits in terms of functional "building blocks," rather than referring to specific manufacturers or part numbers. In essence, this rig is made with a local oscillator running at 10,224 MHz, a mixer, a 10,368-MHz waveguide filter, a 144-MHz IF unit (2-meter all-mode transceiver), and relays.

The local oscillator is the main ingredient and can be created in several ways. For example, assuming an IF of 144 MHz, the local oscillator frequency is 10,224 MHz (10,224 MHz plus 144 MHz equals 10,368 MHz). The LO frequency can be generated using a modified surplus "brick oscillator" running at 10,224 MHz, or a 2556-MHz synthesizer and a quadrupler (times-four multiplier) working together to generate the 10,224 MHz signal.[4] Another LO option is the 10,224-MHz DEMI Microwave Transverter Local Oscillator (MICROLO), available in kit or assembled form. Other LO units are available from other suppliers; take a look at the "Sources of Supply" box for more information.

Power supplies for the various modules can be rather cumbersome, because of the various modules and sub-assemblies requiring different voltages. For example, the rig shown in this article requires +12 VDC, –5 VDC, and +24 VDC, and these voltages must be derived from the automotive 12-VDC (nominal 13.8 VDC) system. Scour the surplus suppliers mentioned in this article to find suitable power-supply components or assemblies. For example, the –5 V DC-DC converter can be found on the surplus market for less than a dollar. The relay voltage converter (12 V to 24 V) can be bought or built, and there are many circuits documented for this purpose.[5–9] In this rig, I used a surplus DC-DC converter module scrounged from a computer power supply. The unit takes 9 V to 15 V DC in, and puts out +12 V, –12 V, and +5 V. Since the voltages are isolated, you can take the two 12 V output voltages and connect the module so that the voltages are placed in series, making 24 VDC to drive the relay coils (see Photo C).

Of course, an AC-operated power supply can simplify the power requirements, but then you may be limited to non-roving operation, unless you have a source

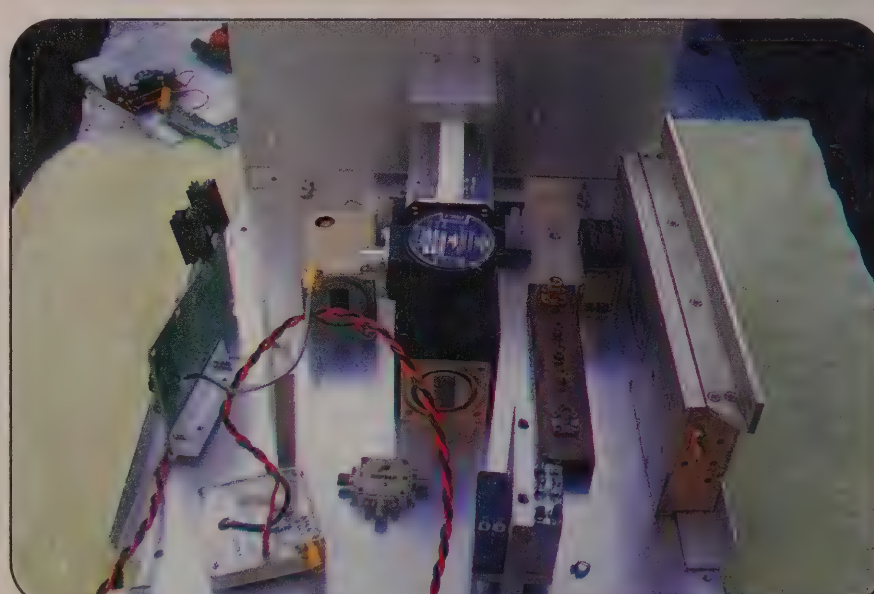

Photo D. The chassis layout is driven by keeping the RF paths as short as possible. DC and control circuits are not as critical, so those modules can be mounted wherever they fit.

of AC power from a generator or other 110-VAC mains electricity.

Always More Than One

When buying surplus material, my practice is to always purchase more than one, since the item may not be available later if (or when) it comes time to repair the unit. Generally my rule is "One to use, one to lose, and one for a spare." Another good reason to buy more than one of the item is its "barter potential." Trading surplus modules from your junk box for a desired item from another ham is a tradition that many microwave project builders rely on. It is also good practice to test your components as soon as possible, or at least before you install them in your project. Pre-testing parts and modules as you build increases your chance of success at first "power-up," and eliminates the need to guess whether or not the completed project will work.

Building Begins

Like almost any other electronic project, chassis layout and metal-working are the next steps (see Photo D). Place the various modules on the chassis so that the shortest RF paths are taken between modules. The DC components, such as the 12 V to 24 V converter, can be moved to the farthest areas on the chassis, because lead lengths will not have as much impact on system performance compared to the local oscillator or the frequency multiplier circuits.

After you have figured out where to put the various modules, it is time to work the chassis, drilling and tapping holes as needed. This "mechanical assembly" includes the routing of any waveguide pieces, since this "plumbing" will mostly be determined by the fittings you have on hand. This is similar to fixing a hot-water heater in your home, but you have only a limited supply of pipes and fittings to use and you have to work with what you have.

When the modules and sub-assemblies are securely mounted, DC power and control connections are done next. This allows DC and ohmmeter testing to verify that each individual module works before proceeding. When the DC checks are complete, continue with the RF wiring.

One of the features I like to include in my projects is a set of "status lights," or "reassurance indicators." These are various LEDs that light up (or do not light up) to verify the presence of voltage as a way to help diagnose a problem in the system (see Photo E). In addition, I have LED indicators on each relay when projects have more than one relay in the system. I first thought that it would be easy to tell if a specific relay has actually actuated by sound or by feel, but this is not the case. It makes more sense to use some other indicator for a better feeling of "reassurance."

The "Ups and Downs"

Be prepared for setbacks and delays while you are building any project using surplus (including "new-old stock") items. For example, the mixer I originally had in the box of parts turned out to not work on X-band. Fortunately, my good friend Dave, WA6CGR, had a selection of mixers to try. Although all of the mixers tested "good" and some of them are in pristine cosmetic condition, only three worked on 10 GHz, and all of them had

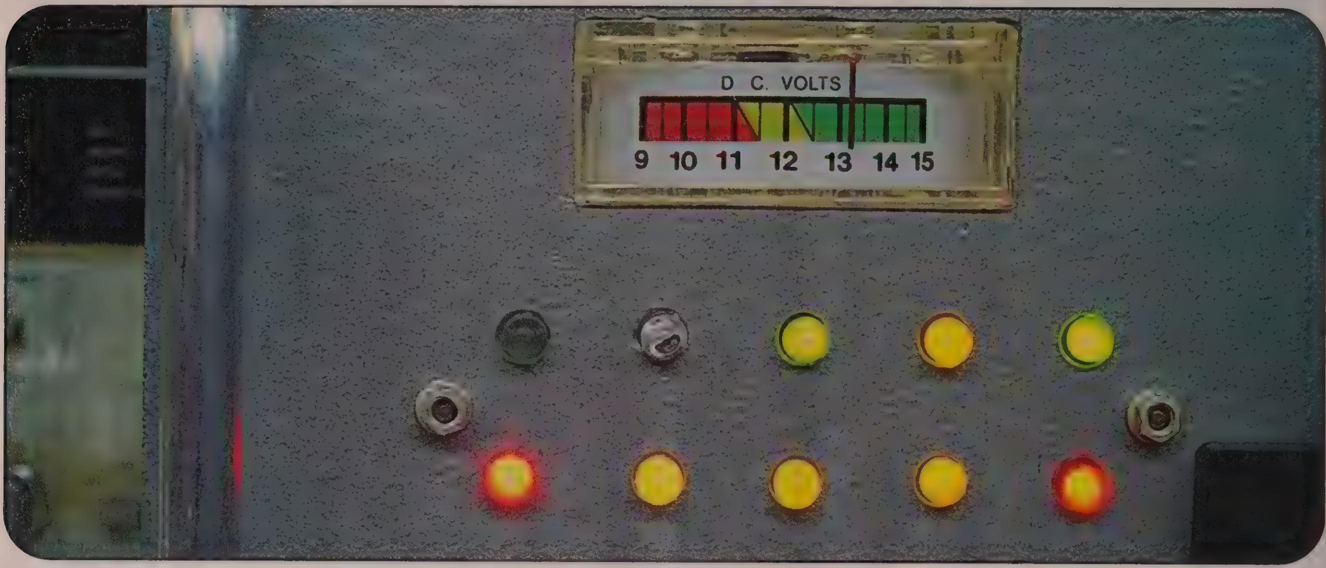

Photo E. The "status panel" helps diagnose simple failures, especially useful in the field. The LEDs indicate voltage is present at the various modules. The top row indicators are for receive and "always-on" functions, such as PLL Unlock (a high-brightness red LED, which turns on when the PLL is un-locked) and 5 V (used for bias power on the amplifier and receiver pre-amp). The bottom row is the transmit function indicators, such as relay actuation and SSPA on.

varying levels of performance. This is another reason to buy more than one item when surplus devices are available.

The Fun Part

Now that the project is complete, it is time to take it out and perform some field-testing. Notice the transverter system has lots of lights, but not many switches or controls. This is done to streamline set-up time and to minimize things to lose or break. For example, there is no main power switch, because the power cable can control the power, which eliminates a switch that can fail.

I hope these hints inspire more people to get on the microwave bands. A rig for 10 GHz is a good place to start due to the propagation characteristics; the two-part ARRL 10 GHz and Up contest; and the availability of microwave parts, kits, and assembled units available to today's experimenters. Experienced microwave hams generally are a helpful lot, since every new station on the air means more points in the next contest!

References

1. Lau, Zack, KH6CP, "Home-Brewing a 10-GHz SSB/CW Transverter, Part 1, *QST*, May 1993, pages 21–28.

2. Lau, Zack, KH6CP, "Home-Brewing a 10-GHz SSB/CW Transverter, Part 2, *QST*, June 1993, pages 29–31.

3. More information on QualComm surplus is posted on the San Diego Microwave Group projects page, on the San Bernardino Microwave Society (SBMS) website: <http://www.ham-radio.com/sbms>

4. Search eBay for surplus brick oscillators; there are many suppliers of this component. One excellent source is an eBay seller called "PyroJoseph" in Florida. A suitable 2556-MHz synthesizer and ×4 multiplier can also be found in surplus QualComm OmniTRACS units, as described on the SBMS/SDMG website, at the URL mentioned above.

5. Jim Klitzing, W6PQL, has a very good circuit for converting 12 V to 28 V for relays using an LM2585. His website is located at: <http://www.w6pql.com>.

6. In the UK publication for microwave enthusiasts, two circuits were described to get 24 V from 12 V. One circuit uses a transistor and a capacitor, and the other circuit uses a 7662 IC and a capacitor. See *Scatterpoint,* September 2004, page 10.

7. Vicor Corporation, in Andover, Massachusetts, makes a variety of 12 V in, 24 V out DC-DC converters that appear on the surplus market. Typical part numbers are VI-203-CX and VI-303-CY. There is also have a good library of application notes and other power supply data. Go to <http://www.vicr.com>.

8. Dave Glawson, WA6CGR, "A Complete X-Band SSB Portable Communications System," *Proceedings of Microwave Update 1991,* published by the ARRL, and online at <http://www.ham-radio.com/wa6cgr/X-Band.pdf>. In Dave's article, a DC-DC converter uses an LM383 audio amplifier chip and three-terminal regulators to convert 12 VDC to various other voltages. With suitable component adjustments, other voltages can be made from Dave's circuit.

9. Glawson has another DC-DC converter for powering microwave projects from 12 VDC. The circuit is based on an LTC1070 switching regulator and three-terminal regulators to make 28 V, –20 V, +15 V, and –5V. Go to: <http://www.ham-radio.com/wa6cgr/ps.html>

Sources of Supply

Down East Microwave. Kits and factory-assembled transverters and other accessories for the microwave ham: <http://www.downeastmicrowave.com>

JWM Engineering Group. Phase-locked oscillators and sequencers: <http://jwmeng.com>

Kuhne Electronic. Michael Kuhne, DB6NT, has a variety of kits and assembled units for the microwave experimenter: <http://www.kuhne-electronic.de>

MPJA Online. A source for general surplus items, including DC-DC converters: <http://www.mpja.com>

SSB Electronic. Supplies kits and assembled units as well as other accessories and items for the microwaver:<http://www.ssbusa.com>

The 10-GHz California to Hawaii Annual Attempt

This July, KH6HME in Hawaii and N6CA in southern California hope to be the first to complete a record-shattering 10-GHz contact via tropospheric ducting. Will they succeed?

By Gordon West,* WB6NOA

July is the magic microwave month for record-breaking tropospheric ducting between California and Hawaii. It was exactly 50 years ago when the late John Chambers, W6NLZ, in southern California completed the record-setting QSO with Tommy, KH6UK, in Hawaii over a path of 2500 miles via "tropo ducting." The contacts were completed with both CW as well as AM on both 144 MHz and 220 MHz.

During this same time, the military, conducting Operation Tradewinds, established near-daily mainland-to-Hawaii contacts on VHF and UHF, with the largest documented number of completed comms occurring in July.

It was 21 years later when Paul Lieb, KH6HME, a California transplant to the big island of Hawaii, completed the first 432-MHz contact with Louis Anciaux, WB6NMT, in July over the 2500-mile tropo-duct path.

In 1980, Chip Angle, N6CA, completed the first-ever 1296-MHz contact with Paul, running 1 watt via a TRW-52601 transistor driven by a Motorola transistor to a rat-race mixer with a milliwatt at 28 MHz for injection. Chip went QRO with a water-cooled 7289 driver tube that delivered 30 watts output to drive a 7289 amplifier for hundreds of watts out.

The July path between southern California and Hawaii is so predictable that Chip and Paul continued to achieve microwave records, conquering 2.3 GHz, 3.3 GHz, and finally 5.6 GHz, where extraordinary path loss is overcome by Chip's homebrew equipment at both ends of the circuit—2500 miles, separated by

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Chip Angle, N6CA (in the foreground), most likely will be the first from California to work Hawaii on 10 GHz. The author is in the background.

The author on 144.170 MHz talking to Hawaii over a 2500-mile path from the California shoreline using a KB6KQ loop antenna.

Hawaii on 10 GHz! Paul Lieb, KH6HME, makes adjustments to his 10-GHz island system aimed at the mainland 2500 miles away.

seawater—and hundreds of dB help from the July weather conditions between California and Hawaii.

As this is being written in mid-June, everyone is hoping that this July Paul in Hawaii and Chip in southern California will be the first to complete the record-shattering 10,000-MHz contact.

"The tropospheric duct improves as the frequency is *increased* until the walls of the duct become too irregular for propagation," commented J. B. Knorr ("Guide EM waves with atmospheric ducts," *Microwaves and RF,* May 1985, p. 67).

"Duct heights of 150 feet to 1500 feet are most common, and seem to be optimum for frequencies on VHF, UHF, and microwaves," commented Joe Reisert, W1JR. This over-water, low-level duct may only be 300 feet thick and routinely forms up high at Hawaii and low in southern California.

"All of my tropo ducting is conducted at the 8500-foot level of the Mauna Loa volcano," said Paul, KH6HME, Hawaii's only active tropo-ducting enthusiast. "Chip Angle, N6CA, has discovered an every-July 'hot spot' at around 300 feet for the best reception of my beacons." Paul's beacons are on: 144.170 MHz, 222 MHz, 432.070 MHz, 902 MHz (on site), 1296.303 MHz, and 10,368.1 MHz (when on site).

The Mauna Loa volcano beacon site is at a wind-swept corrugated-metal "shack" shared with television translator equipment, towers, and power source. The Hawaiian beacons run 24/7 into a variety of stacked Yagis, loops, and microwave to the 48-inch Ku and Prodelin .6f/d offset feed. On X-band, the KH6HME/N6CA-built system yields 10.3 watts at the feedhorn, with a 1.6-dB noise figure at the receiver. WR-90 waveguide and a W2IMU feed provide the hopefully adequate gain of 40 dBi. The entire 10 GHz is frequency-locked to a Ball rubidium frequency standard which has the local oscillator within 1 Hz.

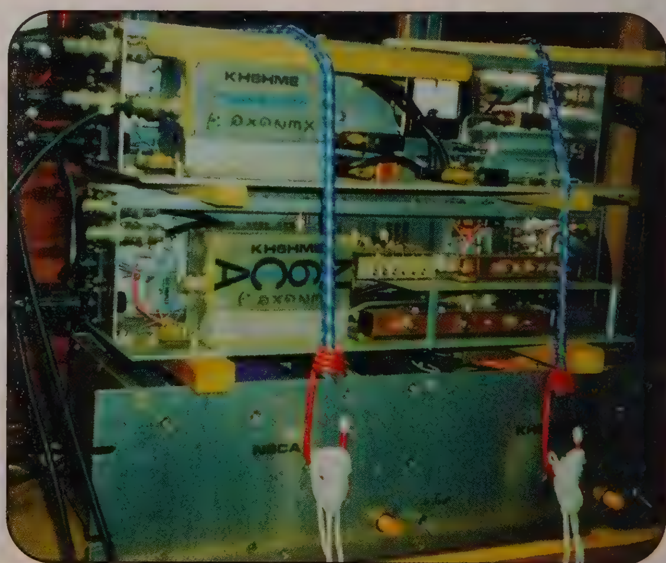
It takes Paul almost three hours to drive from his home QTH near Hilo to the beacon/operating site on the side of Mauna Loa volcano. Paul must navigate a treacherous lava road to get there and bring enough rations in case the band is open for several days.

"When the band opens between California and Hawaii, I am there!" said a beaming Paul, strategically placing food in warm equipment areas so his chow is always warm. During peak tropo times it's not uncommon to hear Paul operating from the remote volcano site for nearly a week!

The July "trigger" to a tropospheric opening is the classic "California High," which settles in between Hawaii and San Francisco. The clockwise motion of the high-pressure cell pulls in surface air and circulates this air *up.* Since there is a greater concentration of air *up high* within this high-pressure cell, the air begins to drop, creating a subsidence inversion.

As the air drops within the high, it begins to compress the air beneath it down to about 1500 feet. As the air gets compressed against the moist air below, it heats up and becomes dramatically dry. This creates both a temperature inversion as well as a vapor content inversion. Pressure also increases within this

Close-up of the KH6HME 10-GHz dish pointed toward California.



The N6CA microwave rack at the KH6HME station on the side of Mauna Loa volcano.

stratified layer, called a *tropospheric inversion.* This atmospheric stratification between Hawaii and the West Coast may become so pronounced that Hawaiians begin hear to southern Californians and FM music stations in Mexico!

"I can tell a lot about how tropo ducting conditions will be by listening to California and Mexico FM radio stations as I drive up the hill to the volcano," said Paul, adding that he always packs his car full of the two-way radio gear right after June Field Day.

This same tropo ducting "high" regularly occurs in July and August all over the United States, too: the Great Lakes to Texas path, Texas to Florida, Nova Scotia to Florida, East Coast to Europe (?), and California to Hawaii always in July!

"*CQ VHF* readers can see the latest equipment for the 10-GHz California to Hawaii tropo efforts at <www.hamradio.com/N6CA>," commented Chip. "To see construction pictures of the 10-GHz KH6HME station, go to <www.hamradio.com/KH6HME> and click on the "construction pictures."

Paul visited the prestigious San Bernardino Microwave Society (www.ham-radio.com/SBMS/) during its January 2007 meeting. There he met all of the members who were preparing for another potential shot at working Hawaii on 10 GHz, with plenty of interest in the higher bands locally, too.

"A large increase in the number of California stations that have 24-GHz capability suggests a possible new plan this year for the 10 GHz and Up contest, sponsored by the ARRL" commented Gary Lauterbach, AD6FP, of the San Bernardino Microwave Society. "For the last several years, most of the contest focus has been on 10 GHz, but now, having many stations on 24 GHz, maybe the time has come to explore and stretch the limits of the higher bands," added AD6FP.

Gary pointed out that by working both bands, 10 and 24 GHz, between a pair of stations doubles the km points that are accumulated, even though the 24-GHz distances are less. "My previous experience indicates that 200-km distances on 24 GHz are routine, and under good tropo conditions contacts out to 300 km are possible," added Gary. So far, the record on 24 GHz is 540 km, with San Bernardino Microwave Society members holding 375 km. "I think it would be a blast to push the envelope on 24 GHz and find out what the limits of that band really are," said Gary.

Tropo-ducting enthusiasts will tell you there is an untapped reservoir of potential microwave operators who are active on 2 meters SSB. Sidewinders on Two, the largest volunteer 2-meter weak-signal organization in the country, suggests joining the group to receive its bimonthly newsletter and continuous updates on all that is happening on 2 meters SSB. Twelve dollars a year is the membership fee for receiving the bulletin by mail, or $6.00 to receive it by e-mail as a registered member. Contact Howard Hallman, WD5DJT, 3230 Springfield, Lancaster, TX 75134-1214 (www.SWOTRC.org).

On our Sunday night net, West Coast SWOT net controllers give the latest on the Pacific high, and newsletter articles regularly focus on tropo paths all over the U.S., with photos and multiple web pages to browse.

Getting on 10 GHz is nearly as easy as getting on 2 meters SSB. In fact, you can turn your 2-meter SSB transceiver into the "business end" of a 10-GHz transverter. The following websites offer nearly "plug-and-play" 10-GHz SSB/CW transverters ready for 10-GHz microwave excitement: <www.downeastmicrowave.com>, <www.SSBUSA.com>, and <www.Prodelin.com>.

"Put up a 10-GHz horn at almost any hamfest gathering, and it is like a magnet, attracting hams to see what happens at 10,000 MHz," commented Kent Britain, WA5VJB, with the North Texas Microwave Society, <www.NTMS.org>, and also the "Antennas" editor of *CQ VHF.*

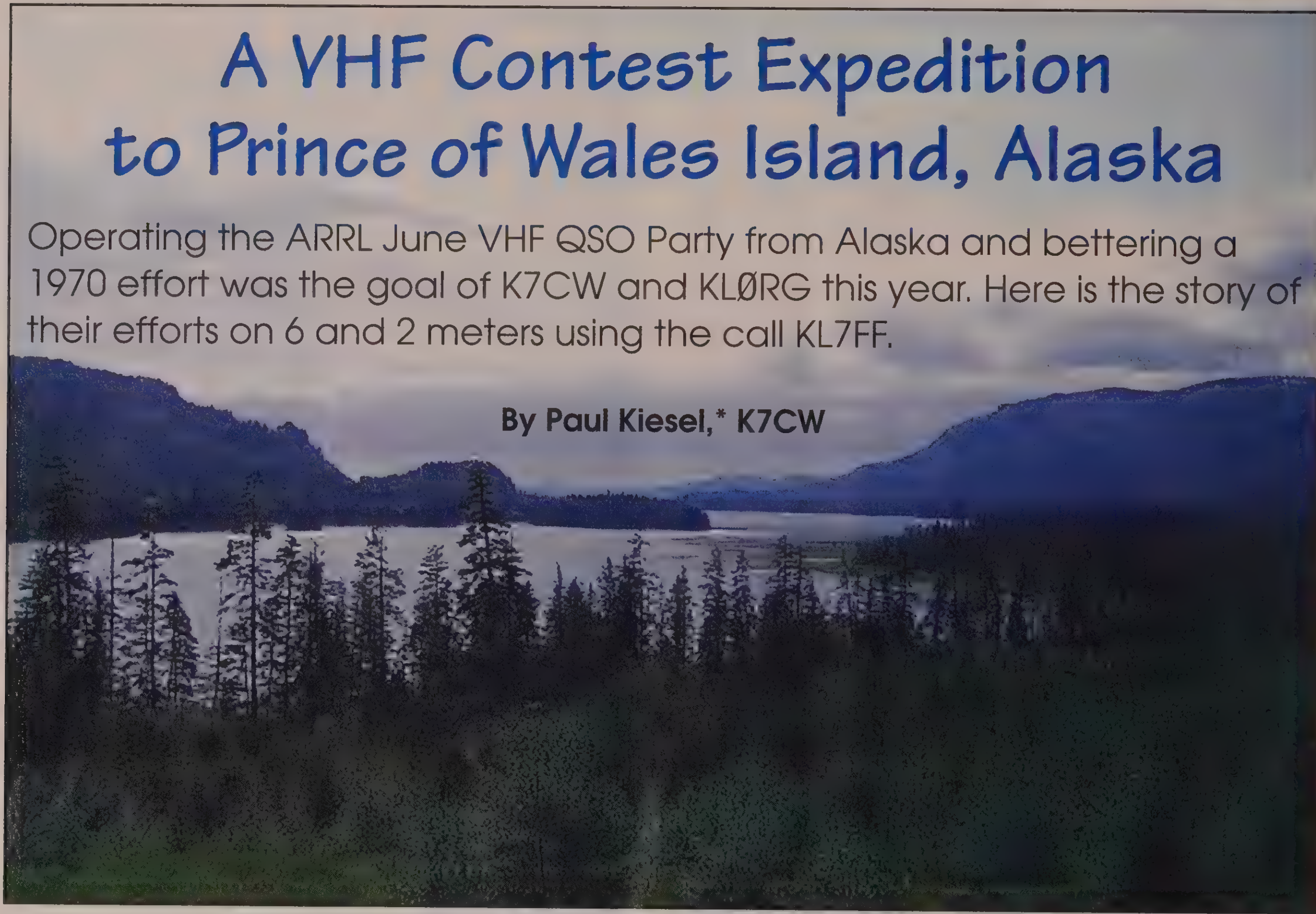
This same "show it off" technique was also a big hit at the recent Amateur Electronic Supply SUPERFEST, with 10-GHz demos put on by the local Badgers Contester microwave team (N8KWX@ARRL.net). The Northeast Weak Signal Group (www.NEWSvhf.com), the Southeastern VHF Society (www.SVHFS.org), and the Central States VHF Society (www.CSVHFS.org) also make it a point to regularly demonstrate 10-GHz equipment.

Explore the microwaves with 10-GHz ready-made 10- and 24-GHz modules. We're just waiting for new ham operators to discover this part of the hobby.

A VHF Contest Expedition to Prince of Wales Island, Alaska

Operating the ARRL June VHF QSO Party from Alaska and bettering a 1970 effort was the goal of K7CW and KLØRG this year. Here is the story of their efforts on 6 and 2 meters using the call KL7FF.

By Paul Kiesel,* K7CW



This is a view of Big Salt Lake on the west side of Prince of Wales Island, Alaska.

In 1970, the moderator of the "World Above 50 MHz" column for *QST* magazine at the time, Bill Smith, then KØCER (now WØWOI), drove his pickup with camper to Ketchikan, Alaska to take part in the ARRL June VHF QSO Party. Bill, using the call KL7ABR, operated the contest in Ketchikan because there were no roads anywhere else near there back then. However, Ketchikan is close to mountains that block any attempt to transmit to the east. Therefore, Bill was able to make contacts to West Coast states only via meteor scatter and sporadic-*E*. There probably was propagation in other directions, but the mountains kept Bill from making contacts in those directions.

Ever since that trip by Bill, I have wanted to do the same. I was hoping to better the effort made by KL7ABR in 1970. Over the last three years, I had strongly been considering the idea of doing the June VHF QSO Party in southeastern Alaska. I discussed this with Kevin O'Connell, KLØRG, and others, but made no decision to prepare for such a trip until 2006, when I retired. I called Kevin early in 2007 and told him that I had decided that this was the year for the contest effort. Kevin, an avid VHF weak-signal afficionado, immediately volunteered, and we became a two-man team for the competition. We would use the DX Scavengers Radio Club callsign, KL7FF.

In the meantime, I discussed the upcoming activity with Ed Cole, KL7UW, who is making great efforts to popularize weak-signal VHF in Alaska. Ed thought it was a great idea to submit a club entry from Alaska. In order to get things going, Ed took steps to make the Alaska VHF Up Group an official organization and obtain club affiliation with the ARRL. Ed published information on his web page, <http://www.kl7uw.com/>, which gave details of our contest plans. He also contacted many Alaskan amateurs and vigorously promoted the VHF contest effort and weak-signal VHFing in general. Unfortunately, the club affiliation didn't arrive in time for the contest, but interest in the activity was still piqued. Excellent job, Ed.

Kevin and I discussed possible locations in southeastern Alaska. Of primary importance was the necessity of having a clear shot with low take-off angle to Canada and the United States. I did a lot of Internet research, seeking possible accommodations. I made many phone calls to owners of vacation and hunting cabins. Some had electricity, but most had unacceptable radio horizons.

Finally, I located a cabin near the eastern shore of Prince of Wales Island, near the town of Thorne Bay, in grid locator CO35rq. From the published Internet photos and from discussions with the caretaker, Tim Lindseth, it appeared that all the necessary specifications would be met. We needed to know for sure, though, that we would have a clear shot to VE and W. A good horizon in the direction of south central Alaska would be a major plus.

At the beginning of May, I flew to Ketchikan to check out the cabin. I met Kevin, who unfortunately had work commitments. However, we were able to take the Inter-Island Ferry to Prince of Wales Island and visit the cabin. We immediately saw that the cabin suited all of our

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Paul, K7CW, on the deck of the M/V Malaspina *on the way to Ketchikan, Alaska.*

Kevin, KLØRG, at the U.S. Forest Service rest stop between Klawock and Thorne Bay, Alaska.

needs, and we made arrangements with Tim, the caretaker, to spend five nights there around the dates of the contest. I then flew back home.

Initially, I had planned to drive through British Columbia to Prince Rupert and then take the ferry to Ketchikan, then another ferry to Prince of Wales Island. The idea was to take my radio and pass out rare grid locators along the route. However, when I checked the ferry schedules, I found that I would have to spend a total of five extra days just waiting in Ketchikan if I went that route. Instead, I decided to take the Alaska Marine Highway System ferry from Bellingham, Washington to Ketchikan, and the mirror image route upon return. That way I would only have one extra day in Ketchikan.

The trip on the AMHS vessel is really a pleasant cruise that takes about a day and a half. The ferry route follows the Inside Passage and is very scenic, with mountains and fjords and virgin forests as far as the eye can see. There is an abundance of wildlife, too, including humpback and blue whales and orcas and bald eagles. I chose not to get a stateroom on the vessel. Brave folks can sleep under the solarium on the bridge deck. It's open to the outside, but has heating elements mounted above so you don't get cold at night.

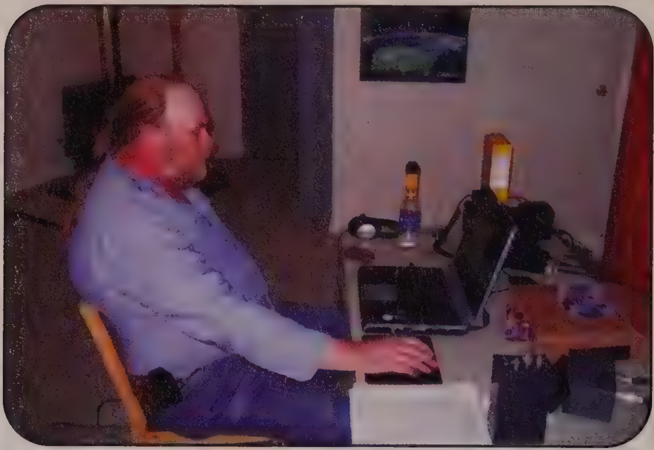
It's a good thing that I chose to take the ferry. As it turned out, there was a large mud slide, with fatalities involved, across the highway between Prince George and Prince Rupert, BC that caused the highway to be closed for several days. If I had taken the land route, I would not have gotten to the cabin in time to operate the contest.

Since I paid to take my pickup on the ferry, I was able to transport anything that I desired from home to Alaska. I took a large portable fan, all my non-perishable food, tower section, rotator, and mast. I took extra coax, coax connectors and adapters, extra power strips, extension cords, rope, radios, a 2-meter antenna, etc. I didn't have to decide what to leave behind, because there was plenty of room for everything I wanted to take. I had already shipped some things, such as the 6-meter amplifier and 6-meter antenna, to Alaska on the barge. When I returned to Washington, I brought everything back with me in the truck, with the exception of the amplifier, which stayed with Kevin.

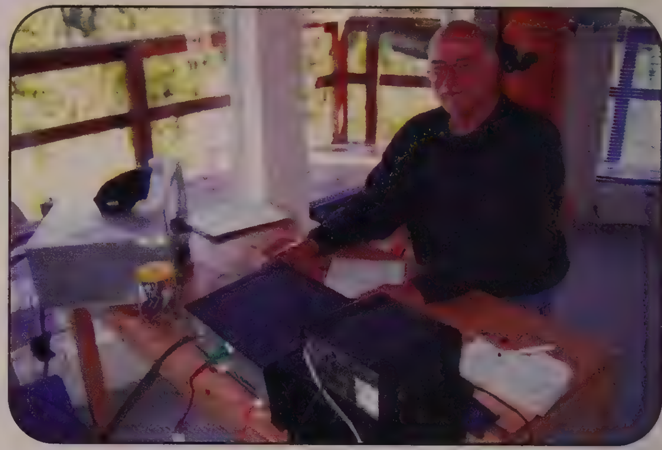
We got to the cabin on the afternoon of the June 7th. The weather was beautiful when we arrived, so there was no hurry to get everything inside. We had scheduled the afternoon and evening of the 7th, all day the 8th, and the morning of the 9th to get ready for the contest. However, no matter how much you prepare, some things don't go as smoothly as you want them to. In our case, I had forgotten to bring my climbing belt to use in mounting the 6-meter beam. I ended up using a few loops of rope around the tower to hold me to it as I lifted the beam over the top of the mast. This was not pleasant! We also had trouble with the T/R sequencer, which caused us some anxious moments just before the contest began.

We got going in the contest on 2 meters and 6 meters, the only bands we had. It didn't take long to start making contacts, but the only propagation mode that we had at the time was meteor scatter. In fact, this was the way it was to be for the entire contest, with the exception of two stations in eastern Washington and the stations in south central Alaska that we worked via sporadic-*E*. All of the stations we worked via sporadic-*E* had strong,

Here is the cabin as seen from the southeast. The 2-meter Yagi is on the porch to the left. The 6-meter Yagi is in the right foreground. The small dish is the satellite internet antenna. The other dishes are various satellite television antennas. All of this was 100% operational while we were there.



Kevin, KLØRG, at the 2-meter operating position of KL7FF.



Paul, K7CW, at the 6-meter KL7FF operating position.

consistent signals over long periods of time. When fading occurred, it was very slow. We did work one station via FM on 2 meters; it was located in Ketchikan in grid locator CO45. He was the only station we worked on a non-weak-signal mode.

The band that holds the most interest for me is 6 meters, so most of my planning was centered around that band. However, I remembered how exciting it was when I worked my first KL7 (yes, it was Kevin) on 2 meters during the *Leonids* meteor shower a few years ago. Kevin volunteered to bring his 2-meter gear, which included a 400-watt brick amplifier. I brought up the 12-element 2-meter Yagi that Kevin had recently purchased. We talked about the probability of making CW or SSB meteor-scatter QSOs on 2 meters during the contest. The *Arietids* meteor shower would be active, but probably could not be counted on to give long enough bursts to get information across in a limited amount of time.

We decided to try the WSJT mode FSK441, and in a few announcements that I made to reflectors before I left, I offered to run skeds during the contest on 2 meters. We received several requests for skeds using FSK441 and a couple for SSB and CW. We completed with everyone who attempted FSK441 contacts with us on 2 meters. We did complete one contact on SSB on 2. In all, we made a whopping 16 contacts in 9 grid locators on 2 meters. Stations in south central Alaska, southeastern Alaska,

British Columbia, western Washington, eastern Washington, Oregon, and Idaho were worked. This success far exceeded our dreams and has to represent a record-breaking performance.

Kevin found that it was easy to get contacts. We had encouraged folks without skeds to tailend after skeds. They did, and they also answered our CQs. We found that it was not hard at all to make contacts on 2 meters from southeastern Alaska! Folks realized that it paid off to go to the trouble of getting digital interfaces connected to their rigs and downloading WSJT. (Actually, we worked a total of 17 stations on 2 meters, having had a FSK441 QSO with a station on June 8th.)

Six meters was a little disappointing because of the scarcity of sporadic-*E*. We were sort of hoping that if there was no sporadic-*E*, then maybe we would have some aurora. A strong aurora would have made things very exciting. Alas, however, meteor scatter turned out to be the predominant propagation mode for us in the contest, and so it was on 6 meters. We had 74 QSOs in 27 grid locators on 6 meters. Not many contacts there, but it's not because we didn't try. There were quite a few partial QSOs that didn't get logged because we didn't get a "roger" from the other station. We did not work a single station beyond one-hop sporadic-*E* maximum range. On this band we ran 600 watts with an 8-element Yagi.

The day after the contest I spent several hours working as many stations as I could on 6 meters. There were some single-hop sporadic-*E* contacts made into Montana and south central Alaska, and a few double-hop sporadic-*E* contacts were made into the Kansas, Oklahoma, and Texas areas. I worked a few stations on meteor scatter, too.

For us, the contest was a success, because we found that it was possible to get on the air from southeastern Alaska and work into areas other than the narrow West Coast corridor to which one would be restricted by operating from Ketchikan. It is still difficult to find a suitable location because of the undeveloped, mountainous character of the entire region. Two-meter contacts between southeastern Alaska and the "Lower 48" have now proved to be an easy thing when using fast digital modes.

This is what sometimes happens when you have only two people to take down a tower with rotator, mast, antennas, and cables still attached!

I would like to thank Kevin, KLØRG; Ed, KL7UW; Bill, WØWOI; Tim and Teresa Lindseth; and all of the weak-signal VHF enthusiasts who offered help, suggestions, and encouragement for this trip. I think we all got a lot out of it. I hope it happens again soon! ■

VHF Propagation Hunter

Tips for Long-Range Terrestrial Contacts on 144 and 432 MHz

WB2AMU presents a brief overview of his chase for long-distance contacts in the weak-signal portion of 144 and 432 MHz while operating portable.

By Ken Neubeck,* WB2AMU

As many VHF operators know, it is a real challenge to make long-range contacts on 144 and 432 MHz via terrestrial means. This is not only because of the need to take advantage of propagation conditions when they happen—such as tropospheric ducting, sporadic-*E,* and aurora—but also because of the apparent lack of monitoring the calling frequencies on these bands on a daily basis by many VHF operators.

Indeed, for the most part these bands do come alive, to a degree, with increased activity during the major VHF contests throughout the year, particularly the ARRL's VHF contests in January, June, and September, when all VHF bands from 50 MHz up to the microwaves are utilized. The CQ WW VHF Contest in July utilizes 50 and 144 MHz, and often both of these bands enjoy significant activity during the contest period.

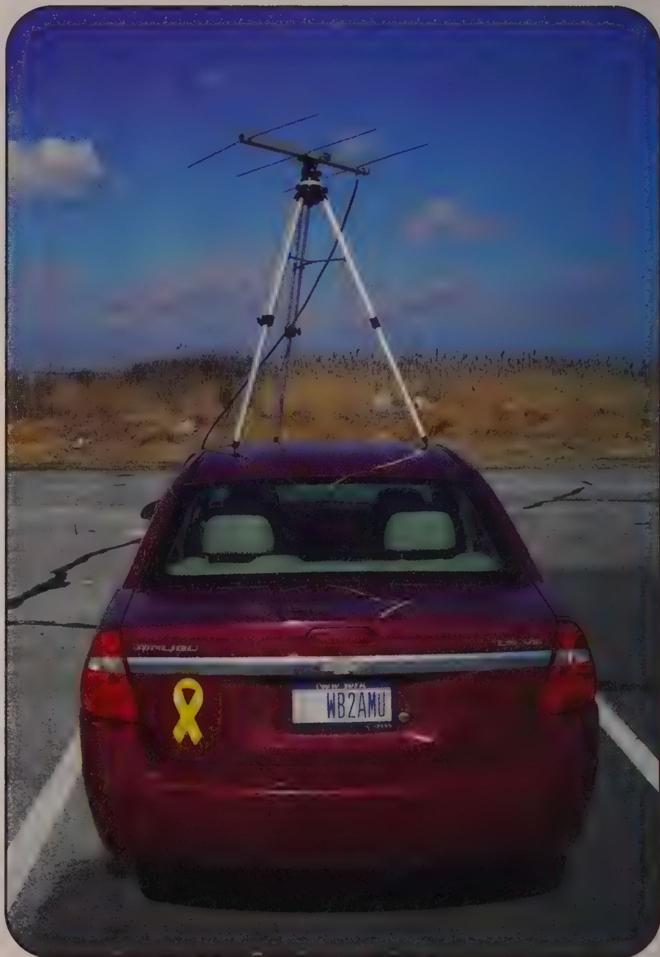
This brings up the real question: What about the rest of the year? Enhanced propagation conditions are present on 144 MHz and 432 MHz at certain times of the year and often are missed because of the lack of day-to-day monitoring by VHF operators. Both of these bands are included in a number of current HF-plus-VHF mode radios, so it becomes a matter of knowing when to monitor the bands.

The following is a brief overview of some of my limited successes chasing long-range contacts in the weak-signal portion (CW and SSB) of 144 MHz and 432 MHz using a portable station, as I do not have a permanent 2-meter station in my house. As I have found, you can have fun chasing contacts on these two bands.

Equipment That Can Be Used for the Chase

Later on in this article we will discuss the various propagation modes that can allow for long-range contacts on 144 and 432 MHz. However, the first question we need to ask is what type of equipment is needed to capitalize on some of these propagation modes and make contacts.

Because of the size of the wavelength for the VHF bands, it is not difficult to have a well-equipped station at home, where



This is a practical portable setup that involves a three-element 2-meter Yagi manufactured by MFJ. It is mounted on a telescope tripod that is resting on the roof of WB2AMU's Chevy Malibu. A short run of RG-8U coax connects the antenna to an FT-100 resting on the dashboard of the car. The antenna installation is very steady, as the weight of the tripod and beam is sufficient to stay in place during moderate wind conditions. This setup works well in the middle of a parking lot. (Photos by the author)

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This is a close-up view of the mounting of the mast of the 2-meter Yagi to the platform of the tripod, where the telescope normally would be mounted. There were some pre-drilled holes that were in the mast portion of the beam, allowing for attachment screws and nuts to be added for securely mounting the antenna.

a multi-element Yagi is used up 50 to 100 feet on a tower. In addition to the multi-band radios that have 144 MHz and 432 MHz, there are plenty of linear amplifiers available for these frequencies. A home station with multi-element Yagis and amplifiers will do well with all of the propagation modes mentioned earlier in the article.

However, when working long-range contacts, it is possible to do quite well with portable and mobile setups for these bands. A major advantage of a portable setup is the ability to pick out a suitable site in terms of height and reduction in noise level. Indeed, VHF hill-topping has been a pastime of mine for close to 40 years. Major improvements in equipment and antennas have made my operations more feasible without a lot of effort.

All of the contacts listed in the tables in this article were completed using portable and mobile setups. For the most part, I used a Yaesu FT-100 with no amplifier (50 watts maximum on 144 MHz, 20 watts maximum on 432 MHz) and a simple three-element Yagi up as high as I could get it. During the big sporadic-*E* opening on 144 MHz last summer, I did not have a beam with me and I used a vertical with decent success! Would a better setup have made a difference? The answer is yes and no. I think with regard to aurora contacts, higher power and higher antennas would have helped. A portable setup seemed not to be an issue with regard to most tropo-enhanced conditions and with those rare sporadic-*E* openings on the 2-meter band.

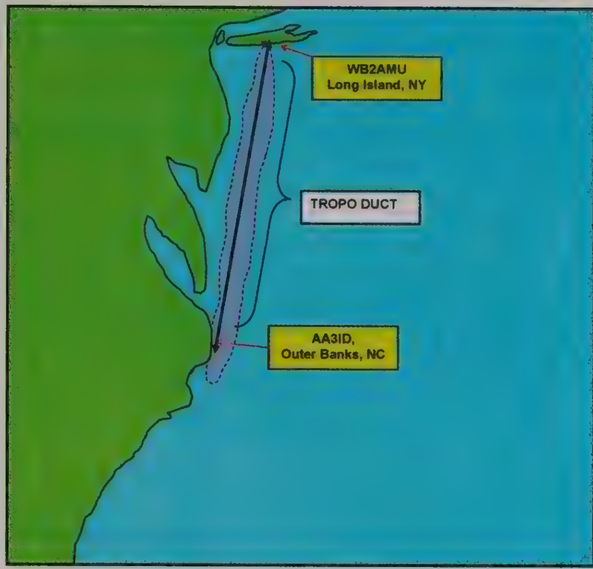

Figure 1. This image of the eastern coastline of the U.S. shows the tropo path between Long Island in New York and The Outer Banks of North Carolina. From this map it can be seen why the path ends at The Outer Banks area, since from that point, the coastline slants toward the west, making it harder for a duct to turn in that direction from The Outer Banks. On occasion, this path has been experienced during the summer months, and on rare occasions during the fall and mid-winter when conditions are just right.

I used to use an umbrella stand to support the masts holding my VHF beams. Recently, I obtained a telescope with tripod assembly as a gift for my years of service at my job. I have yet to use the telescope itself! However, the tripod assembly is very handy as a mount for my 2-meter beam on top of my car roof. The tripod can extend up to 5 feet, and on top of the car the overall height is 9 to 10 feet, which is generally sufficient for most 2-meter contacts, particularly in an enhanced location such as on a hill. I was able to find suitable hardware that would allow me to mount my three-element MFJ Yagi to the area where the telescope normally would be. See the photos with this article, which show the details of the assembly. I was able to use this setup successfully for 144 MHz as well as 432 MHz QSOs with the 2-meter beam during the ARRL's June VHF QSO Party.

Tropo Conditions

In recent years, I have experienced some amazing long-range contacts via tropo ducting on both 144 and 432 MHz. A close ham friend of mind, Van Fields, W2OQI, who is very active

Date	Time (UTC)	Callsign	Grid	Freq. (MHz)	Mode	Antenna	Power
June 9, 2002	1311	W4FSO	FM14	144.2	CW	3-el 2 meter Yagi	10 W
Nov. 23, 2003	2340	AA3ID	FM25	144.2	SSB	3-el 2 meter Yagi	35 W
June 13, 2004	1147	N4HB	FM17	144.2	SSB/CW	3-el 2 meter Yagi	10 W
Feb. 8, 2005	1720	AA3ID	FM25	144.2	SSB	3-el 2 meter Yagi	35 W
Feb. 8, 2005	1725	K4HHT	FM25	144.2	SSB	3-el 2 meter Yagi	35 W
Sept. 8, 2006	2151	AA3ID	FM25	432.1	SSB	3-el 2 meter Yagi	10 W

Table 1. Selected list of long-range VHF tropo contacts made by WB2AMU (FN30).

with the Coast Guard Auxiliary on Long Island, New York, alerted me to the fact that often on the Marine VHF Channel 9 calling frequency (at 156.450 MHz) or Channel 16 distress frequency (156.800 MHz) he hears the Coast Guard station on The Outer Banks, North Carolina coming into his area on eastern Long Island. However, at the same time, he does not hear all that much amateur radio activity on the 2-meter band; not many take advantage of this opening, except for a few out-of-town repeaters being heard in the FM portion of the band.

Tropo conditions seem to favor the warmer months of summer, particularly when there are a lot of cold and warm fronts passing through different areas. Some very well-known paths have been documented in various articles, such as the southern California to Hawaii path, where hams with HTs on the beach in California can work into Hawaii *(see "The 10-GHz California to Hawaii Yearly Attempt," by WB6NOA, elsewhere in this issue of* CQ VHF*—ed.).* Here on the East Coast, the path from Long Island to The Outer Banks of North Carolina is an occasional one that shows up during the summer months and sometimes during the winter when certain weather conditions occur.

Based on my limited experience, I have found that enhanced tropo conditions seem to happen during the early morning and early evening hours. However, I have experienced enhanced conditions during the middle of the day and well into the late evening hours, as shown in the data presented in Table 1.

The VHF contests seem to bring stations out of the woodwork, as decent levels of activity can be heard in the weak-signal portion of 144 MHz with spotty activity on 432 MHz. For me it seems that usually during a VHF contest there is maybe one unusual contact on those two bands, either long distance or a rare grid.

One such highlight occurred during the September 2006 ARRL VHF QSO Party shortly before 6 PM local time on Saturday night. I was switching back and forth between 144 and 432 MHz while using the same antenna, an MFJ three-element 2-meter Yagi. Suddenly, on 432 MHz I heard a very loud SSB signal. I dropped in my callsign and AA3ID from FM25, located on The Outer Banks, came back to me! He apparently QSYed to 432 MHz from another band, looking for a station that had requested he go there. He was 59 with tropo distortion, and I was 57 for him using just 10 watts and the 2-meter antenna! The map shown in Figure 1 shows this path, one that has occasionally occurred between Long Island and The Outer Banks. Please note from Table 1 that I have made other contacts with AA3ID via tropo and at different times of the year!

An important website for predicting tropo conditions is provided by William R. Hepburn (http://www.dxinfocentre.com/tropo.html). This site predicts potential tropo openings for the upcoming five-day period for different areas of North America and uses color-coding to rate intensity of the tropo paths.

Another thing to remember regarding tropo conditions is that conditions can change during the course of a day or even a particular hour. For example, there are many times during a VHF contest when pointing towards a certain direction will yield little results in working stations. Then an hour later, a small tropo path may develop towards that direction and signals may be of significant signal strength so that they can be worked.

During the 2007 June VHF QSO Party, I saw how moderate tropo paths could be fickle on a band such as 144 MHz. During the Sunday morning of the event, 144 MHz had moderate activity toward the northern part of New England, but I heard nothing to the south. Then by 8 AM, I worked a pair of stations in the Maryland area on 144 in grids FM19 and FM18.

This is the 2-meter antenna/tripod assembly in action during the early morning hours on a hill on central Long Island (grid FN30) during the ARRL June 2007 VHF QSO Party. The setup performed satisfactorily, with grids as far north as FN43 and as far south as FM18 worked on the 2-meter band.

Tropo is the bread-and-butter mode for the 144- and 432-MHz bands, as paths capable of extending signals can occur several times a year. Thus, tropo becomes a more practical mode of propagation for these bands, compared to aurora and sporadic-*E*. More daily monitoring of the 2-meter calling frequency of 144.200 would be a good strategy to catch these paths, and then moving to 432 MHz could be an additional step to check conditions there.

Aurora Conditions

For the years preceding and especially for the year following a solar cycle peak, aurora conditions occur on an occasional basis on the VHF bands when geomagnetic activity increases. Most openings occur on 6 meters, and when density of the aurora formation increases, activity can occur on 144 MHz and on rare occasions 220 MHz, and even less frequently on 432 MHz.

Table 2 shows a list of selected contacts that were made by me during some intense aurora openings that reached the level of 144 MHz. All of the contacts that I made on 144 were during the years following the solar peak, and they all were made

Date	Time (UTC)	Callsign	Grid	Freq. (MHz)	Mode	Antenna	Power
Mar. 31, 2001	1835	VE3AX	FN02	144.1	CW	3-el 2 meter Yagi	40 W
Apr. 11, 2001	2314	K9MRI	EN70	144.2	CW	3-el 2 meter Yagi	40 W
May 29, 2003	2044	K4QI	FM06	144.1	CW	3-el 2 meter Yagi	40 W
Nov. 20, 2003	3257	K1GUP	FN54	144.1	CW	3-el 2 meter Yagi	40 W

Table 2. Selected list of long-range VHF aurora contacts made by WB2AMU (FN30).

Date	Time (UTC)	Callsign	Grid	Freq. (MHz)	Mode	Antenna	Power
July 6, 2004	2200	KX9X	EM59	144.2	SSB	1/4-wave vertical	40 W
July 6, 2004	2208	KC4PX	EL98	144.2	SSB	1/4-wave vertical	40 W
July 6, 2004	2212	KD4ESV	EL87	144.1	SSB	1/4-wave vertical	40 W
July 6, 2004	2218	W4HP	EM75	144.2	SSB	1/4-wave vertical	40 W
July 6, 2004	2220	N9LR	EN50	144.1	SSB	1/4-wave vertical	40 W
July 6, 2004	2223	NW5E	EL98	144.1	SSB	1/4-wave vertical	40 W
July 6, 2004	2256	KB4TCU	EM81	144.1	SSB	1/4-wave vertical	40 W

*Table 3. Selected list of long-range VHF sporadic-*E *contacts made by WB2AMU (FN30).*

on CW. It is almost impossible to make an SSB QSO via aurora on 144 MHz, as the signals are very wide because of the effects of aurora, and voice signals would be distorted even more than those heard on 6 meters!

One of the more amazing contacts from this list was with K9MRI from EN70 in Indiana. I clearly remember how strong his signal was during the opening. Also, after experiencing many aurora openings on 6 meters and not usually reaching out to the EN grid on that band, I was surprised to hear someone from that grid field on 144 MHz and was able to work him using a very modest portable setup in my driveway, where the antenna was only up 10 feet on mast sections!

While aurora events occur primarily during the equinoxes, some occasional events can occur at other times as well. Some intense openings have been observed during the months of May through August. In fact, the 2004 ARRL June VHF QSO Party saw a significant aurora opening on the Sunday afternoon of the contest, where signals were heard on both 50 and 144 MHz.

Even though we are in the valley of the sunspot cycle, 2-meter aurora is still potentially possible over the next few years when a major eruption occurs on the sun. However, this type of geomagnetic-storm activity is more likely to occur in the 2009 to 2011 timeframe. Again, a good indicator of potential events are the various solar websites, such as <http://www.dxlc.com/solar/indices.html>.

Also, it is important to note that aurora will first appear on 6 meters, before the density of the aurora formation makes it possible for aurora signals to be heard on 144 MHz. Usually when signals become very strong on 6 meters and many start appearing, it is prudent to check the 2-meter weak-signal calling frequency of 144.200 MHz.

Sporadic-*E* Conditions

Sporadic-*E* on 144 MHz is a fairly rare occurrence, with one or two openings being observed in the U.S. during the course of the summer season. During the winter sporadic-*E* season, it is very rare for the density of sporadic-*E* formations to reach the level of reflecting radio signals on 144 MHz and above. Thus, the focus for hunting 144-MHz sporadic-*E* should be during the summer season, beginning in May and ending in late August or early September.

The key to spotting a potential 144-MHz sporadic-*E* opening is to keep an ear on 6 meters. When the skip starts to shorten up on 50 MHz, where signals at distances of less than 800 miles or so are being heard at very loud signal strength, it is a good time to listen on 144 MHz, usually around 144.200 MHz.

When signals start to appear on 144 MHz, there may be instances of rapid increases in signal strength and rapid fading. The trick is to move quickly and exchange information during such an opening, as the opening may last for only 15 to 20 minutes.

One of the biggest openings that I have been fortunate to take advantage of in recent years on 144 MHz took place in July 2004. I was out doing some errands, and stopping at my father Ray, W2ZUN's house, I saw that many channels were severely impacted by interference on his TV hooked to an external antenna. Indeed, sporadic-*E* interference was reaching as high as Channel 7 (which is in the 175-MHz range)! Unfortunately, I only had a 1/4-wave whip antenna for 144 MHz in my car, but in spite of this shortcoming, after leaving my father's house I went to a parking lot and started working stations on 144 MHz. The skip lasted for over two hours, and my results with the vertical are shown in Table 3.

When it does occur, 2-meter sporadic-*E* propagation is a major event. As indicated before, when certain conditions start to occur on 6 meters, it may warrant listening on the 2-meter band. Also, making use of internet websites as well as other means, such as Broadcast TV or FM radio, may be a tip-off that an opening is in progress.

Summary

This article provides a little insight into some of my recent modest successes in chasing long-range 144- and 432-MHz contacts using terrestrial modes and mainly a portable setup. It can be seen that activity on the VHF bands remains a significant issue on a day-to-day basis outside of the VHF contest periods. In the future, I hope to provide some updates in on additional observations from 2007 and beyond. ■

ANTENNAS

Connecting the Radio to the Sky

Weak-Signal Mobile Antennas

Back in the late 1940s and the early 1950s, there was considerable discussion about the advantages of horizontally versus vertically polarized antennas for long-haul VHF/UHF QSOs. When considering propagation, it doesn't really matter if the signals are horizontally or vertically polarized, but there are mechanical advantages to each. As a result, SSB and CW generally are used from home stations and the antennas are horizontally polarized. Mobile stations usually find it much easier to put up a vertical whip antenna, so most mobile station antennas are vertically polarized.

Therefore, when it comes to mobile SSB/CW operation, you have the challenge of coming up with a mobile horizontally polarized antenna. However, 6 meters is rather an exception. When the 50-MHz SSB signal bounces off a few *E*-layer clouds during an opening, the sig-

*1626 Vineyard, Grand Prairie, TX 75052
e-mail: <wa5vjb@cq-vhf.com>

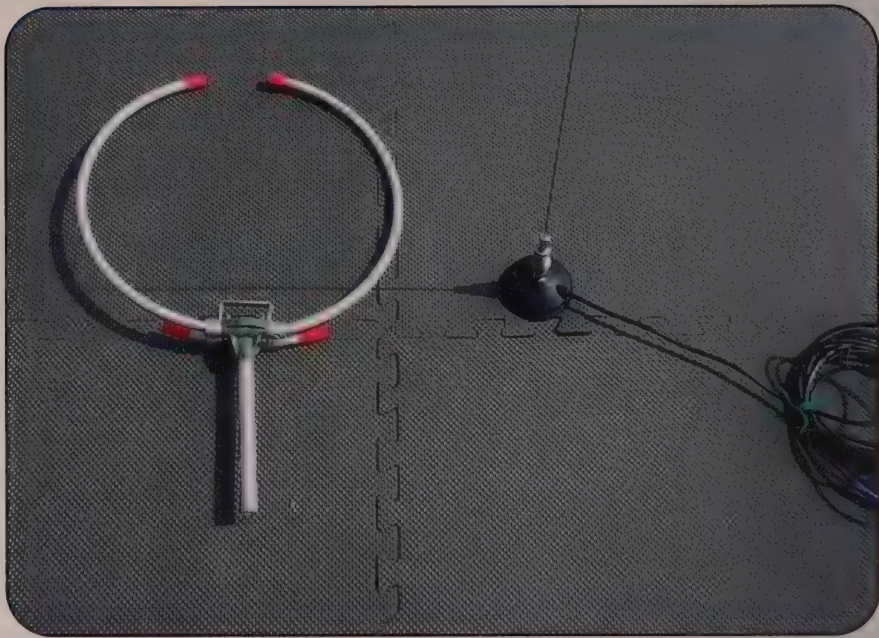

Photo 1. A 2-meter halo for horizontal polarization and a 2-meter vertical for vertical polarization. (Photos by the author)

Photo 2. My 2-meter squalo, which has had a long and hard life.

Photo 3. A 432-MHz magnet-mount halo.

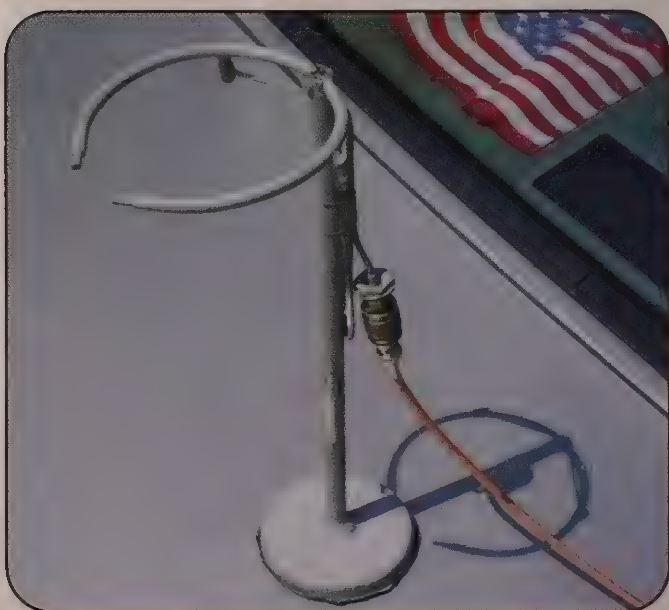

Photo 4. Close-up of the halo matching.

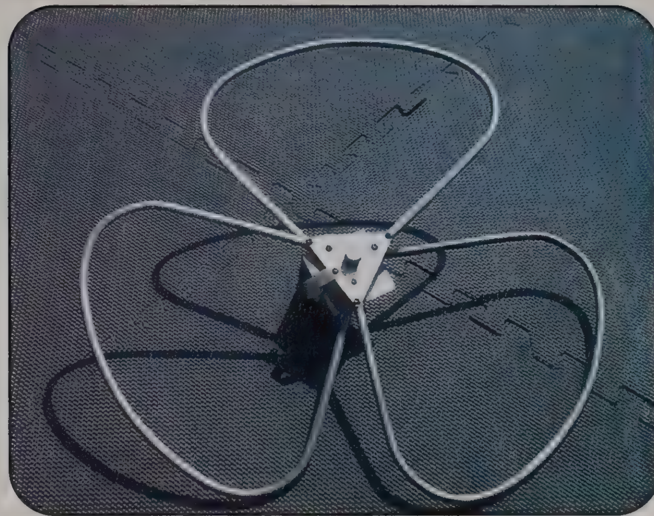

Photo 6. The 432-MHz "Big Wheel" antenna.

Photo 5. The M2 6-meter "halo" antenna.

Photo 7. K5VH's 144-MHz "Super Wheel" antenna.

nal that bounces back has a confused polarization. Thus, a vertical antenna works almost as well as a horizontal antenna on 6-meter skip. I worked more than 30 states with an ICOM IC-502 (3 watts on a good day) and a 2-meter 5/8-wavelength mag-mount antenna on top of a 1977 Chevette. I'll bet, though, that I got something mixed up there. No, a 5/8-wavelength antenna is electrically 3/4 wavelength long, but is shortened to physically be 5/8-wavelength long. That's why there is a tuning loop in the base of a 5/8-wavelength antenna, to get that extra 1/8 wavelength. Therefore, the 2-meter 5/8-wavelength mag mount is also a 1/4-wavelength whip on 6 meters. It works great with some of the new multiband rigs as well.

The Halo and Squalo

In Photo 1 we have the most common VHF horizontal mobile antenna, the halo, and a 1/4-wavelength mag mount. In its simplest form, the halo is just a 1/2-wavelength dipole bent almost into a circle. Capacitance coupling between the tips can be used to shorten the antenna even more, but at the expense of a narrower bandwidth. This halo certainly has seen a rough life, and it uses a beta match, or a shortened stub, to get the feedpoint impedance back to 50 ohms.

In Photo 2 is my veteran 2-meter squalo. It was a used antenna when I got it 25 years ago. I added another 100,000 road miles, and forgetting to take the squalo off several times before pulling into the garage has created its share of wear and tear. However, it still works. This squalo uses a gamma match, which is an offset feed with some series capacitance. Personally, I am not fond of gamma matches, but they do work. The half of the dipole with the match on it has the most RF current, which makes the maximum radiation off the back corner of the squa-

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Photo 8. The 2-meter DDRR mobile antenna without its cover.

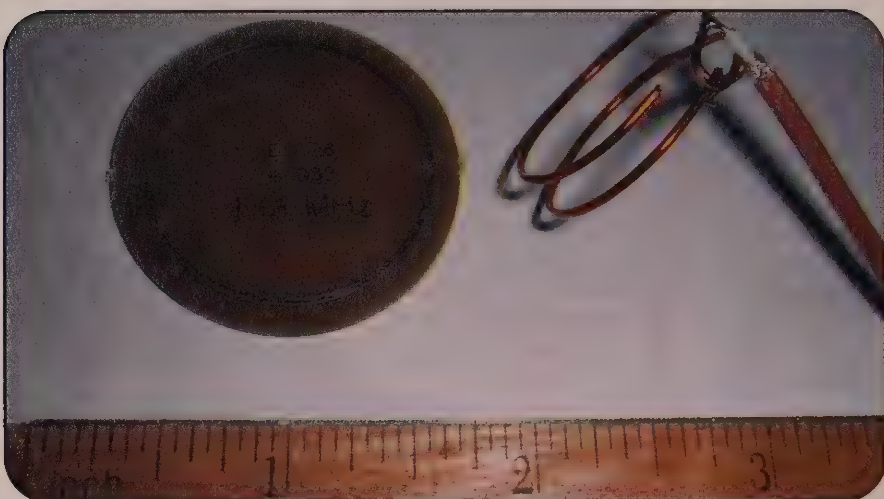

Photo 9. Shown here are 433-MHz and 915-MHz DDRR antennas

lo on the side with the match. Thus, gamma-match squalos are not exactly omnidirectional.

I dug out my 222-MHz halo antenna, but it seems that it didn't survive an avalanche in my garage last winter! Well, it was tuned to 220.1 MHz when I first used it mobile. However, I digress. Terry, W5ETG, has spent a lot of time tweaking mobile antennas, and he suggested I use a balanced feed on my 220-, 432-, and 1296-MHz halos. In Photos 3 and 4, I show my 432-MHz halo using the balanced feed. It has a 4:1 coax balun and equal-length matching arms on both sides. Tuning with Terry's match was smooth and broadband. It's certainly worth the extra effort.

In Photo 5 we have one of the M^2 mobile antennas. Mike Staal uses a halo-type antenna with lots of capacitive coupling on the ends to keep the size more practical. He also uses "magnetic coupling" between the coax and the halo. The coax drives a small loop inside the larger loop. This behaves much like a transformer, with the relative size and position of the loops controlling coupling and impedance. I have built several halos in this way. It's rather touchy to get it right, but once you have the combination dialed in, you have a very efficient and omnidirectional antenna.

The "Big Wheel"

Next is the 432-MHz "Big Wheel," sometimes called a "Clover Leaf" antenna (Photo 6). The wheels are much larger than the halos. In exchange you get about 2 dB more signal, better bandwidth, and they work nicely on their third harmonics. Therefore, a 144-MHz wheel can also be a 432-MHz mobile antenna, or the 432-MHz wheel can be used on 1296 MHz.

A 1/4-wavelength antenna must have a ground, and the bigger the ground the better. Halos and squalos do not need that. Halos, squalos, and wheels close to the ground form a sort of two-element Yagi with the beam (or main radiation lobe) of the antenna pointing straight up.

The "Super Wheel"

The next step up is the "Super Wheel" developed by K5VH (Photo 7). The Super Wheel has more gain than the normal wheel, and while it has a bit more wind loading, it is similar in size to the normal wheel antennas. For information, contact Tom at <K5VH@arrl.org>.

The DDRR

Here we have a very different species of antenna, the DDRR, or Directional Discontinuity Ring Radiator (Photo 8). While it looks like a horizontally polarized antenna, the loop is working with the ground plane to form a slot antenna, and the slot is vertically polarized. Thus, the DDRR is a very low-profile, vertically polarized antenna. For those of you who work in the low-power wireless field, I'm told that someone claims to have a patent that covers all "inverted-F" antennas. Inverted-Fs are very popular small antennas for cell phones, ZigBee[1], etc., applications. Actually, the DDRR is an inverted-F antenna, and the 40-meter version was written about in *QST* in the early 1970s, based on work done in the 1950s. I think some "prior art" on that patent can be shown. I have some 146-, 440-, and 915-MHz DDRR prototypes in the shack, and they have quite a few uses for those of you with only a few inches of clearance between your car and the garage door. In Photo 9 is shown a 915-MHz DDRR made of #22 copper wire, and a 433-MHz DDRR etched on PC board. I'll try to finish a DDRR for a future column.

For now it's summertime and a great opportunity to get more antennas in the air. As always, I welcome questions and suggestions for future topics.

73, Kent, WA5VJB

Note

1. ZigBee is a specification for a suite of high-level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks. *(Courtesy Wikipedia)*

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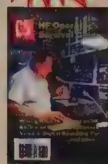

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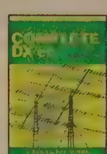

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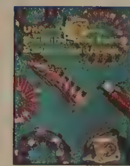

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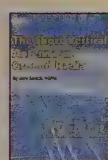

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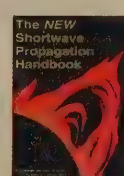

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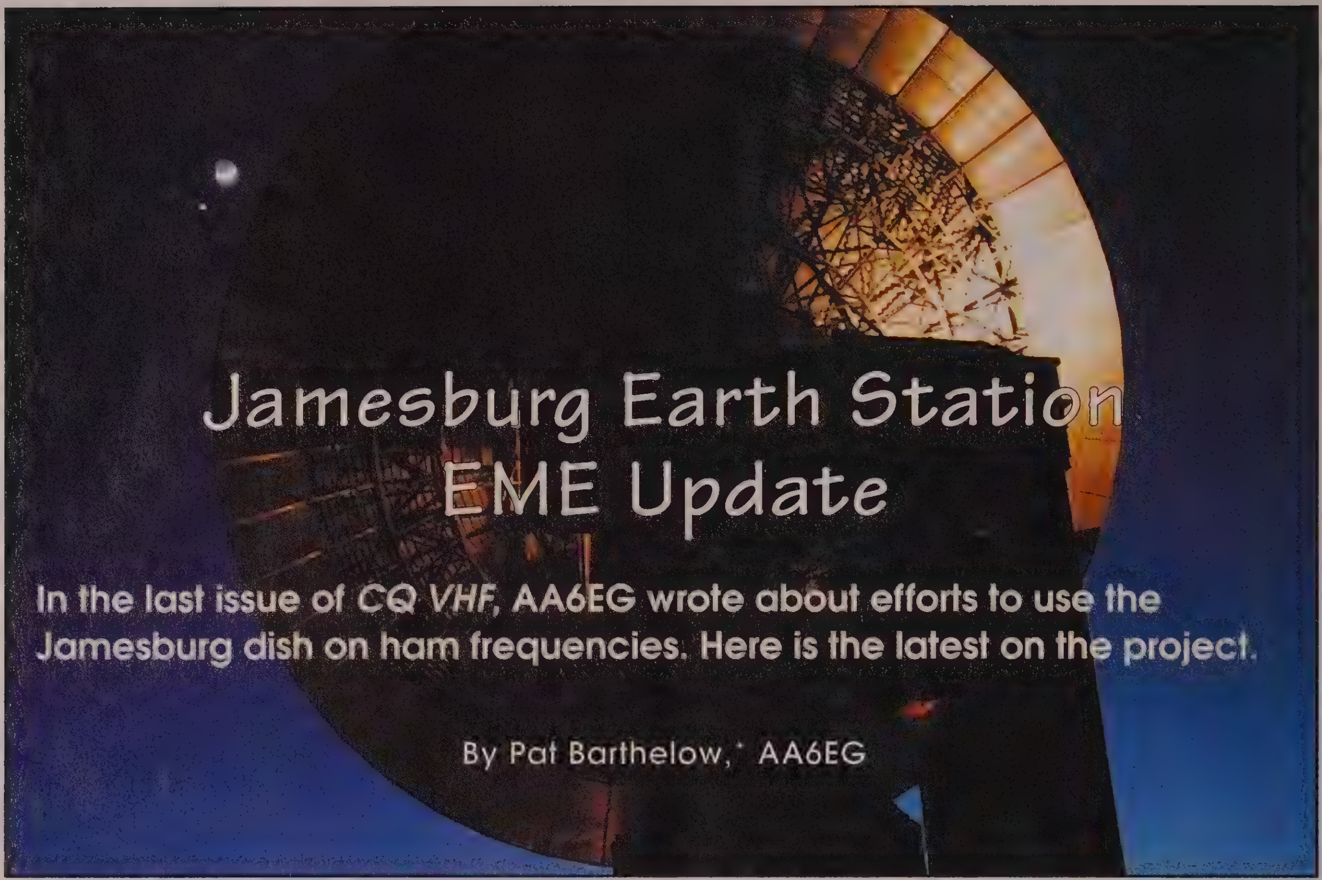

Jamesburg Earth Station EME Update

In the last issue of *CQ VHF*, AA6EG wrote about efforts to use the Jamesburg dish on ham frequencies. Here is the latest on the project.

By Pat Barthelow,* AA6EG

This is a spectacular "over the shoulder" nighttime view of the Moon and Venus as "seen" by the Jamesburg dish. (Photo by Rex Allers, KK6MK)

I would really like to thank the *CQ VHF* magazine staff and editors for polishing and printing our Jamesburg Earth Station team's EME story. The Jamesburg story continues. Since the article in the Spring 2007 issue of *CQ VHF* was wrapped, we have achieved some very successful and fun EME contest operations and experimented with some sub-optimal 144- and 440-MHz near-prime focus feeds. Our intrepid volunteer team has gained complete precision control of the dish, both in azimuth and elevation.

Within the team, our software guys—led by Kevin Hague, N5XSA, and Rex Allers, KK6MK—have refined the dish-control software, so much so that Kevin demonstrated to us how the main program keeps the very tight beam created by the 30-meter dish actually centered on the moon's surface. Kevin created a great graphic of the moon that has a tiny dot representing the center of our beam. With

This photo was taken at the Jamesburg station during the 1296-MHz EME contest in May 2007. Left to right: John Hagerty, W6UQZ; Marc Goldman, WB6DCE; Goran Popovic, AD6IW; Rex Allers, KK6MK; Kevin Hague, N5XSA; Andre Barbe; Jim Moss, N9JIM; and Brian Yee, W6BY. (Photo by KK6MK)

*599 DX Drive, Marina, CA 93933
e-mail: <aa6eg@hotmail.com>

the laptop joystick, Kevin steered the beam around on the moon's surface while we listened to the return signals, and it was very cool! As expected, we could hear the return signal drop off rapidly in real time as we moved the beam off-center of the moon. This was a great reality check that told us that the beam is indeed tight and symmetrical at 1296 MHz and is correctly boresighted with the AZ/EL sensors of the VERTEX dish drive system. With this insight as to the accuracy of the program we can now lock in the beam center anywhere on the moon's surface with ease.

We have some preliminary results from our dish metrology expert, Mike Brenner, of <http://www.engr-metr.com>. We know from his laser measurements that the dish structure is extremely rigid, with an RMS surface change of only 10 to 14 mils between extremes of vertical angles. We hope the surface accuracy of the Italian-made Cospal panels are equally as good, but need more design dimensions of the two reflector surfaces to determine the current dish accuracy.

We are still looking for solutions to the long-term preservation of the Jamesburg station and hope that someone from the space, private, university, military, and/or philanthropic sectors comes forward to work with us to build a business model and give resource support to keep Jamesburg for the long term. We currently can accept tax-deductible donations to the effort through an interim partnership with a 501c(3) sponsoring organization. We have plans to create our own Jamesburg 501c(3) entity in due time.

Some photo credit corrections for our Spring 2007 *CQ VHF* magazine article need to be mentioned here, particularly for the cover picture, which was taken by Rex Allers, KK6MK. Congratulations, Rex (and Gerald Moseley, who is correctly credited with the inset cover shot). Thor Rasmussen, N6FNP, took the photo of our planning meeting on page 7, and also the shot of Bryan Yee, W6BY, about to unlatch the access hatch from the access ladder below the dish (page 10).

If you are interested in keeping apprised of our progress, then please check out our website: <http://www.jamesburgdish.org>, or contact me at: <aa6eg@hotmail.com>. ■

Remembering W2UK/KH6UK

Tommy Thomas, W2UK/KH6UK, was one of the most accomplished VHF-plus operators of the 1950s and '60s. Here, thanks to some assistance from his nephew Mark Shultise, WA3ZLB, is a brief history of this world-renowned amateur radio operator.

By Joe Lynch,* N6CL

The following are excerpts from my September 2005 and November 2005 "VHF Plus" columns in *CQ* magazine, along with a couple of minor updates since their publication.

As they do almost every year, over this summer Chip Angle, N6CA, and Paul Lieb, KH6HME, again have been working on setting a new 10-GHz record between California and Hawaii via the now well-known tropospheric duct between the West Coast and Hawaii. As of this writing, it is not known if their attempt has been successful. The attempt was made possible because of the pioneering work of John Chambers, W6NLZ, and Ralph E. "Tommy" Thomas, W2UK.

It was on July 8, 1957 that John and Tommy (using the call KH6UK) made contact on 2 meters. It would be about two years later, on June 22, 1959, when they again would set a record by making another contact, this time on 220 MHz.

Who was Tommy Thomas and how was it that he ended up in Hawaii to set these records? What follows are the results of some sleuthing and at least one fortunate coincidence of history that opened a major door, which is where I need to begin my story:

When I first looked up KH6UK in preparation for this piece, there was a note on the website that he was a Silent Key. I contacted Fred Lloyd, AA7QB, the owner of QRZ.com, who graciously supplied me with the information as to who inserted the note. It turned out to be Tommy's nephew, Mark Shultise, WA3ZLB, the son of Tommy's sister, Freda Shultise. Mark, like his uncle, had moved to Hawaii in 2003, approximately 48 years after Tommy's relocation. I am deeply indebted to Fred for assistance in contacting Mark.

*Editor, CQ VHF
e-mail: <n6cl@sbcglobal.net>*

Now to some history that I uncovered as a result of Mark's assistance and my on-again and off-again years of investigation of Tommy's accomplishments.

A Bit of History

Ralph E. "Tommy" Thomas was born on December 22, 1903 in New Brunswick, New Jersey, the son of Mr. and Mrs. Robert L. Thomas. Tommy's ham radio accomplishments were first on HF. According to Philip Peterson, W2DME, Tommy started his ham radio career in the spark-gap days. During the 1920s and 1930s Tommy "was constantly improving his equipment and was recognized for his special ability in radio communications."[1] According to *The Sunday Home News*, New Brunswick, NJ, Sunday August 4, 1957, these accomplishments included:

> Tommy's 1926 feat of communicating with the George Miller Dyott expedition at the River of Doubt in Brazil, when all commercial efforts to reach the party had failed; and the July 1938 effort when he was one of three amateurs to provide up-to-the-minute weather data for Howard Hughes in his historic globe-girdling flight.
>
> Of the River of Doubt contact, *The New York Times* termed it "an almost impossible feat."
>
> There are few better known amateur radio operators in the world than Thomas whose reputation has been enhanced by the years running in 1938 by virtue of making 329 contacts in 70 countries. Prior to that he had finished second and third and since then has been among the leaders many times.

After World War II, Tommy's interest in the hobby turned toward VHF. Again quoting Peterson, "Tommy said, 'I wanted to try something new after World War II. I started to explore the possibilities of increasing the communications distance range of the VHF and UHF spectrum.'" Tommy entered that spectrum with the same enthusiasm that he showed on HF before the war.

One of his early accomplishments was participating in the first amateur transmission using transistors, which was made in late 1952 when K2AH, using a one-transistor transmitter, worked Tommy on 2 meters some 25 miles away. The power output of that single-transistor transmitter was 50 microwatts.[2]

By December 1952 he was listed in *QST*'s "World Above 50 Mc." 2 Meter WAS standings as having worked 21 states in 7 call areas with the greatest distance being 1075 miles. Tommy would make history beginning the next year when he and Paul Wilson, W4HHK, began running schedules on 2 meters, leading up to the first 2-meter meteor-scatter contact—a feat that would earn both of them the ARRL's 1955 Award of Merit.

According to interviews I had with Paul and Tommy in 1994 in the run-up to the 40th anniversary of their QSO, their interest in the challenge of making a 2-meter meteor contact began in June 1953 when Paul and Ross, W4AO, were in contact via a tropo path. After the path fell apart, Paul continued to hear signal bursts. Ross advised Paul that these were meteor bursts. Within a few days of this contact, Paul got a letter from Tommy asking him to set up schedules for a possible 2-meter contact via any mode of propagation. Paul responded that he'd like to try to work him via meteor scatter.

Over the next several months, schedules were set without success. Then on the morning of October 22, 1954, it all

came together. Tommy copied more than two minutes of transmission from Paul, and he in turn was able to copy Tommy's confirmation and signal report. With that exchange they snagged the first complete 2-meter QSO via meteor scatter.

It is interesting to note that because this mode of propagation was experimental, there was no definition of what was considered a QSO. Therefore, Paul and Tommy looked to the ARRL—specifically to Ed Tilton, W1HDQ, then editor of *QST*'s "World Above 50 Mc." column—to define what was necessary for a completed contact. Ed determined that both operators had to acknowledge to one another that they had received both calls and the correct signal report; the latter had to be confirmed by repeating the signal report received back to the other operator.

Reliance on Ed's definition led to the rejection of Paul and Tommy's first claimed contact in August 1954. It wasn't until the second contact that both of them received enough information from one another for Ed to consider the QSO complete.

Their QSO was considered such a breakthrough in propagation that Paul's audio tapes of the meteor-scatter contacts were played at a meeting of propagation physicists of the International Scientific Union (URSI) in Washington, DC, in May 1954.

According to the October 1956 issue of *QST*,[3] as a result of this presentation, Ed, W1HDQ, was asked to prepare a summary of the work and supply some samples of the recorded signals for presentation at the General Assembly of the URSI to be held in The Hague in September 1954. The presentation also included a talk by Dr. J. T. de Bettencourt of MIT's Lincoln Laboratory. The audience was made up of the leading propagation physicists from most of the countries of the world, prompting the *QST* author to comment: "Thus scientific attention was focused on one of the worthwhile aspects of amateur radio that has had too little recognition—our ability to contribute to man's knowledge of wave propagation phenomena."

All told, it took Paul and Tommy two years of constant scheduling to finally make the contact. In their experimentation they tried high-speed keying and tape-recorded playback in their efforts to complete a QSO. Each station was running near-legal-limit power into high-gain antennas and preamps that had a noise-figure measurement of nearly 2 dB. During their experiments they were convinced by the regularity of the bursts that they were dealing with meteor-scatter propagation.

One needs to realize that in those days we did not have WSJT software, and the mode of communication was CW. Additionally, the sophistication of the radios was such that each operator had to tune the receiver with its analog dial in order to locate the signal. In spite of these restrictions, Paul and Tommy eventually were able to complete the QSO and make their entry into the history of VHF communications.

At the time of their QSO Tommy was working for RCA as the engineer-in-charge at the RCA transmitter station on outer Easton Avenue in New Brunswick, New Jersey. Operations ceased there in 1955, and Tommy was transferred to a similar post in Kahuku, Oahu, of the Territory of Hawaii. At that QTH he acquired the KH6UK callsign and relinquished the W2UK callsign for a few years. It seems that in the early 1960s, he did reacquire the W2UK callsign, because according to *QST*[4] he made his historical 1296-MHz EME QSO with W1BU as W2UK/KH6. Yet according to Al Ward, W5LUA, who reports in the May/June 2007 issue of the North Texas Microwave Society's newsletter "Feedpoint," Tommy made the QSO as KH6UK. More on his EME exploits follows below.

Tommy's transfer to Hawaii might have seemed a setback for others due to the limited opportunities to make contacts on the VHF-plus frequencies. For Tommy, it proved to be a new challenge.

Contacting VHF enthusiast John Chambers, W6NLZ, Tommy set about duplicating his feat with Paul, this time between Hawaii and California. Knowing little about the actual propagation mode of meteor scatter (that being the ionization of the *E*-layer and its characteristic limitations on distance to approximately 1300 miles), Tommy assumed that there was no reason why he could not complete a QSO with John.

It would be two years of 20-meter skeds before they made contact. Oddly enough, the QSO took place on July 8, 1957. Coincidentally, the contact took place "at virtually the same time a massive meteor flared in the Hawaiian skies."[5] This coincidence led Tommy and John to believe that their contact could have occurred as a result of meteor-scatter propagation. Even so, they also thought that it might have been a freak atmospheric effect.

Setting out to determine what might have been the cause of the successful contact, they started making skeds on 220 and 432 MHz. It would be nearly two more years, on June 22, 1959, before they completed a contact on 220 MHz. John reported that he did hear Tommy on 432 MHz; Tommy heard nothing. It was later determined that a receiver problem on the Hawaii end probably prevented a two-way QSO.[6] Incidentally, their 220-MHz QSO has never been bested, thereby making it the first tropospheric contact on that band, and the longest lasting VHF DX record to date.

For their accomplishments, they won 1960 ARRL Merit Award and the 1961 Edison Award. For the latter, each received a trophy and split a $500 cash award.[7]

Not much is known about Tommy subsequent to his EME accomplishments in the 1960s. He is in the record books for having made contact with W1BU via 1296 MHz on July 31, 1964.[8] It appears that after his retirement from RCA he moved back to New Jersey, settling in Farmingdale.

Concerning Tommy's VHF-plus accomplishments, Mark wrote: "As for the Hawaii to California contact, they made the attempt a number of times and just happened to get the call through.

"He also had performed some moonbounce in his experiments. When I asked why try to bounce a signal off the moon, his answer was pretty much 'because it was there.' It was not the best reflector, but its position in the sky was pretty easy to track."

Mark added:

> I'm not sure where Ralph was at the time, but I believe it was Hawaii. Ralph answered the door and there was a truck driver with a big dish on it. "For me?" was his question. Yes, it appears RCA thought he might like a bigger antenna to play with. When he moved, the antenna stayed put! Some of his tubes came from the Varian brothers, who thought he might like some extra power to play with.

Tommy became a Silent Key on May 8, 1996. Commenting on Tommy's death, Mark stated:

> I'm not sure why, but even members of his family learned of his death after the fact. His equipment may have been donated to friends or the local Ham Club. I don't even know where his logbooks ended up. To my knowledge, he only lived in two towns in NJ in the years before his death, Colts Neck and Farmingdale.

In my e-mail exchanges with Mark, he advised me, "Years before Ralph's death I visited him in New Jersey and surprised him with the information that I was now a Ham. We chatted about some of his accomplishments and so on. We talked about his providing weather reports for Howard Hughes's round the world flight. He was quite a good friend of Howard it seemed."

I am deeply indebted to Mark for supplying me with text of the two New Jersey newspaper articles. Making contact with Mark has been a wonderful window into Tommy's life.

Ironically, as I mentioned above, at the time I first started my investigation for this piece Mark had made a note on Tommy's listing on QRZ.com about Tommy being a Silent Key, which opened the door to contact him via Fred Lloyd's assistance. Unfortunately, that note has disappeared with the reassignment of Tommy's KH6UK callsign to Douglas M. MacDowell of Belleview, Washington this past March. Tommy's W2UK callsign was reassigned to Joseph Fernandez of Teaneck, New Jersey this past February. Such are the effects of the vanity callsign program.

Here is the story of how Mark ended up in Hawaii approximately 48 years after his uncle had relocated there.

Mark's initial e-mail intrigued me because he began it by writing, "Aloha Joe." Who else but someone living in Hawaii would greet someone with the word "aloha"?

It turns out that after an initial vacation trip to Hawaii in 2002, Mark decided to return there for good. He has become a Kona coffee farmer and lives on the big island of Hawaii. His QTH is Captain Cook, which is a two-hour drive from Pahoa, which is the QTH of Paul Lieb, KH6HME, who is the Hawaiian side contact for the potential 10-GHz QSO. What an incredibly small world we have! For more information on Mark, please see his website: <http://myhawaiiansite.com>.

I have forwarded Paul's phone numbers to Mark and will leave it up to them to make contact with one another. Hopefully, the nephew of the pioneer of the California to Hawaii duct might possibly be a witness to another pioneer set yet another record between California and Hawaii.

My September 2005 piece on Tommy Thomas, W2UK, resonated with three hams—Bud Weisberg, K2YOF, Dennis Kopecky, WJ2R, and Van Field, W2OQI—who had their personal recollections. While Bud gave me some insight into Tommy's switching between the calls KH6UK and W2UK, Dennis and Van wrote reflections from their having actually known Tommy. What follows are their comments.

Dennis, WJ2R, wrote:

> I really enjoyed the Tommy Thomas article in September *CQ* magazine, and as requested I have a bit of a memory on Tommy that wasn't mentioned.
>
> I had just gotten my ham license in March 1964 (effective the 17th, St. Paddy's Day), and begun my subscription to *QST*, after reading sporadic copies that came my way, either through the junior high school library (oh, thank God, for that nasty old lady) or from various ham friends.
>
> Anyway, I had already gotten to work 2 meters AM with a Gonset II and was encouraged to go over to the ARRL National Convention at the New York Hilton, in August, by my "new" friends I was meeting on those frequencies.
>
> I remember riding up the elevator to the ballroom with Tommy, and remember all the adulation he was graciously receiving as the very nice guy he was. I remember the badge showing the KH6UK call, and I'm not sure if he also had something on as W2UK. The ARRL Nationals, judging from what I saw there, had to be the "Dayton" of that day and age, the gathering of the many and the mighty!
>
> The conversations by those riding on the elevator with me seemed to be welcoming him back to New Jersey and inquiring about whether he was here to stay. So, I could only assume, being the wide-eyed teenager for whom this was all new, that he was some sort of notabl, and well regarded. I remember him as a nice guy, shorter than me, and balding, upper middle-age, who for some reason I always wondered about all the years after, what became of him, and of course, learning later on, of his accomplishments.
>
> I never worked him or heard him on the air, as this was easily possible from my Linden, NJ, QTH then and now. But at least now we can know that one of his activities during that rather sparsely known period was to go to that event. Whether he was a speaker at one of the various presentations or forums, I don't remember; I don't know whether I saved the program or not, or if it would still be around here. Maybe some more research in *QST* would have included program highlights in the issues preceding the convention.
>
> About the only other speculation I have of Tommy was that living in the Colts Neck area, he had to be acquainted with Carl Scheidler, W2AZL—another one of our VHF pioneers with his widely built and known AZL converter for 2 meters—if the two of them were ever to discuss 2 meters and VHF in general! I think Carl worked for the Bell Labs facili-

ty over there in Holmdel, and when I did finally meet him at his QTH, I was surprised that his station was just a modest, average looking one with an average amount of equipment, and compared to some of the stations now on the covers of *CQ* would have paled by comparison.

I was privileged to meet W2AZL through Ron Todd, K3FR (then WA2JAM), who also designed and built his own converter, which later appeared in *73 Magazine.* I would think Ron's mentor was W2AZL, which is why I think Ronnie made it a point to meet up with and be friendly with Carl.

Ron and I, and his cousins, who were not hams, met at Drexel University (Institute of Technology back then; I was in the last graduating class of DIT; next year, it was DU!). Ron's father, W2UM, (SK, mid '70s) worked at RCA in Somerville, and I can't help thinking, with a call as close to Tommy's, that they too had been acquainted, maybe even having taken the tests together. Perhaps Ron would have some memories of things his father, Paul, might have said along the way that referred to Tommy. Or you could maybe pick Ronnie's brain for a future article on Carl. I know Ron and I had also talked about VK3ATN's work, with moonbounce from Australia, and we were both members of W3MGF, Drexel's ham radio club. At that time, I was WB2MXZ, and I haven't talked to Ron since maybe the time when his father passed on.

The sad part about it today is that with all the FM and repeater work, sure there are plenty of stations on those frequencies, but so few of us are around who would consider or are working with experimenting with the other modes and propagation. It's going to be left to the commercial interests soon, and there's so much fun to be had if people would realize that there is life after the repeater!

There are a number of us here in NJ who are actively refurbishing any of the old Gonsets and Cleggs we can find, and some schedules are being set up once they are up and running. I can count 13 of us in various stages of keeping these antiques active, and more are in the thinking about it process. Whether any of us ever gets to build some of the old circuits anymore, with all these all-mode rigs available, remains to be seen, but at least some of us remember how it once was.

That ARRL convention was a real eye opener, as I probably brushed elbows with Ed Tilton, W1HDQ, a tall, thin, bespeckled gentleman, and didn't even know why I should be happy to get to meet him. And then there was Leo Meyerson, WØGFQ, cigar in mouth, in person, hawking his World Radio gear from all the catalogs I had read, for the days when I'd set up my own station. Of course Heathkit was there, and what a brilliant idea the Heath Monitor Scope was; you could see where there was a station on the band and you could pounce on if you liked! Gus Browning, W4BPD, might have even been there, as I remember Collins pushing his exploits with its equipment.

Ah, those were such "Good Old Days," "Golden Years" in ham radio. Hope you enjoyed this walk down memory lane.

Van, W2OQI, wrote:

Your piece on W2UK sort of rang a bell when I saw it. His VHF-UHF operation from Hawaii was sort of a second career in the spotlight. I knew Tommy when I was a teenager. I also used to meet him for an RCA get-together in Riverhead a few years before he went SK.

He lived in Quogue on Montauk Highway. The wooded lot west of his house was used to hold the rhombics he used to keep in contact with Howard Hughes on his round-the-globe flight. They had a commercial license for that.

He won the DX contest in 1937 and 1938, the only person to win two years in a row back then. Eimac or maybe Taylor used his feat as an ad with his rig in *QST.*

Also in Quogue were resort hotels. One was run by my father (later W2PDU). He knew Tommy because Tommy married his head waitress. By the way, Tommy arranged for my first job interview!

I guess all this goes under the heading of trivia. Tommy liked to do things that others didn't bother to try I guess. I imagine his VHF operations were inspired by Gil Wickizer, W2DOG, another engineer at RCA in Riverhead. He wrote several papers on VHF-UHF propagation for RCAC.

While this piece has not covered all of Tommy's life, it does address some of the highlights of this important pioneer of the VHF-plus ham bands. *(Also see the article "The Lost Letters of KH6UK, Part 1, by WA2VVA, on page 16 of this issue.)* Compiling and writing this article was a labor of love—love for the hobby and love for the preservation of its history. I am deeply indebted to those who assisted me in my efforts. Thank you for playing a part in bringing to print our wonderful history so that future pioneers in our hobby can emulate and make contributions to its ongoing success.

Notes

1. <http://www.infoage.org/p-43W2uk.html>)
2. *QST,* February 1953, p. 65.
3. *QST,* October 1956, p. 62.
4. *QST*, September 1964, p.e 96.
5. *The Sunday Home News,* New Brunswick, NJ, Sunday August 4, 1957.
6. *QST,* September 1960, p. 78.
7. *The Home News,* January 21, 1961.
8. *QST*, September 1964, p. 96.

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

The View from the Edge of Space

Twenty years ago, I watched a video of Joe Kittinger parachuting out of a Project Man-High research balloon from 103,000 feet above the Earth. The view was incredible. You could see the curvature of the Earth and the blackness of space. The ride he took back to the ground was just plain amazing, and he was falling so fast he nearly broke the sound barrier.

This inspired in me the strong desire to visit the edge of space (also called Near Space), and it dawned on me that there had to be a lower cost and much safer way of experiencing this. At the time I was very active with Amateur Television, so I figured I could send a live TV camera to the very edge of space and back again using a weather balloon. From 100,000-plus feet, I could see what Joe Kittinger had seen, but I could do this by watching the view on my TV set in the comfort of my ham shack.

My first flight was on August 15, 1987 from Findlay, Ohio and carried a 1-watt ATV transmitter and a 50-milliwatt 2-meter FM transmitter. At peak altitude the low-power ATV and 2-meter signals were copied beautifully in Chicago, some 250 miles away. As those who have ever tried mountaintopping can attest, antenna height is everything!

You can see 400 miles in all directions from a balloon at 100,000 feet. The first time I sent a film camera up on a balloon, I anxiously took the film to be developed. When I went to get my processed film from the photo shop, the fellow who worked there asked me, "How'd you take these photos; are you an astronaut?" With a view like this, just imagine what kind of coverage you can get with a balloon-borne VHF or UHF repeater. Contacts between hams over 700 miles apart have been made this way, often using nothing more than HTs on the ground. How's that for a wide-coverage repeater? Just think of the emergency communications possibilities; one balloon payload can cover an entire Katrina-size disaster area.

ARHAB

Since 1987 I've flown over 200 balloons from 19 states. In addition, quite a number of balloon groups from across the country have popped up over the years. Called ARHAB (Amateur Radio High Altitude Ballooning), this is a great way to put some new excitement into amateur radio and combine the best elements of specialized digital and video modes (APRS, CW, PSK31, RTTY, and ATV), homebrewing (build your very own satellite), ground and mobile tracking station design, and of course, the ultimate in foxhunting challenges. It's an exciting way to attract newcomers into ham radio, particularly among the young people, where the Internet, webcams, and cell-phone text messaging compete with amateur radio. Let them know that they can build, track, and recover their very own satellite and this definitely captures their interest. Many of the young engineering students who participated in the local university's BalloonSat course got their amateur radio licenses strictly for the balloon flights. Once they saw how exciting ham radio can be, they went on to become active members of our local radio club.

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Photo A. A typical BalloonSat flight system. (Photos courtesy of the author)

The BalloonSat

A typical balloon flight consists of a latex weather balloon and a parachute with the experiments dangling below (see Photo A). Dubbed a BalloonSat, they quite literally are very low-cost satellites that you can fly right to the very edge of space for hundreds, instead of millions, of dollars.

Up to 12 pounds can be flown under FAA rules (no more than 6 pounds in any payload). Most groups adhere to this rule, but some of the larger groups, universities, and government agencies do fly much larger experiments, which require a waiver from the FAA.

The typical ARHAB mission takes about 90 minutes to reach 100,000 feet. At that point the balloon has expanded to its max-

imum size due to the near vacuum environment and bursts. The parachute inflates and brings down the experiment to a gentle landing place some distance away from the launch site, usually taking about 40 minutes. Fortunately, we now have prediction software that allows us to use FAA winds aloft data and forecast the landing zone fairly precisely.

The Chase

Part of the fun is chasing the balloon and recovering the payload. There are a number of amateur radio operators who will jump at the chance to tromp through the woods, climb mountains, or hike across fields to find these experiments once they've landed. A balloon chase basically is a foxhunt on steroids, with the added challenge that no one quite knows exactly where the transmitter will land. Most balloon trackers have APRS and a laptop with a mapping program that plots the balloon's position in real-time, and some just rely on good, old-fashioned direction-finding techniques, which often are needed if the primary APRS transmitter fails (see Photos B and C).

Live on the Internet

You can actually participate in a BalloonSat flight from your home computer. Those flights that carry APRS on board will link up directly to <www.findu.com> and also <www.aprsworld.net> in near real-time on a moving map display thanks to a network of APRS Internet gateway stations. You can see the altitude, course, and speed during the mission.

For those interested in participating in a flight, there a number of websites to help get you started:

http://www.arhab.org: There are now so many balloon groups that fly each weekend that you likely can find a flight nearby. The ARHAB website is a wealth of information that includes launch announcements and details of flights worldwide. Web links to many balloon groups are also listed, in addition to a Balloon Records page. There is even an annual contest for a variety of categories relating to amateur radio ballooning. This year's categories are: Highest Altitude, Longest Flight Time, Longest Downrange travel, Greatest Telemetry Reception Range of a balloon's signal (VHF/UHF and HF), and the Greatest Distance Two-Way radio contact using a balloon as a repeater relay.

http://www.eoss.org: The website of one of the largest balloon groups based in Colorado, this site is a wealth of information on getting started in high-altitude ballooning. Check out the links for FAA regulations concerning balloon payloads and download Balloon Track from the software section to help plan your very own flight.

http://www.nearspaceventures.com: This website has a link called "Web Based Balloon Track," which is a very useful tool to help predict your balloon's flight path plotted on a Google map. The Near Space Ventures group is based near the Kansas City area and does a number of flights involving the Civil Air Patrol and Boy Scouts.

http://www.superlaunch.org: This is the website for our annual high-altitude ballooning conference, called the Great Plains Super Launch. Typically held in Nebraska, Iowa, or Kansas, each summer balloon groups from across the nation attend this event for a day-long conference to share payload ideas as well as launch and recovery techniques. The next morning they hold the Super Launch, where ten or more balloons are launched at once. It's an amazing sight to behold, and chasing

Photo B. The KBØYRZ balloon chase mobile. Left to right: Joe Lynch, N6CL; Jim Harper, KCØSHZ; Mark Garrett, KA9SZX; and Chris Krengel, KBØYRZ.

ten balloons is an experience that is not soon forgotten. This year's event will be held on July 6–8 in Grand Island, Nebraska.

http://www.wb8elk.com: This site has launch announcements for my flights, which typically are flown from the southeastern states. In addition, details on the upcoming 20th anniversary of ARHAB celebration in Findlay, Ohio can be found. This event will be a Super Launch to commemorate the 20th anniversary of my first flight and will be held on the morning of August 11th.

In addition, there are a number of Yahoo discussion groups pertaining to ARHAB flights. Check on the ARHAB links section of <www.arhab.org> for a list of these. One great place to start that will get you in touch with some very experienced high-altitude balloon folks is <GPSL@yahoogroups.com>.

In future columns, I plan to feature balloon groups from around the world and cover ways to take amateur radio to new heights using weather balloons, hot-air balloons, radio-control airplanes, kites, and even rockets. 73, Bill, WB8ELK

Photo C. Recovering the WB8ELK ATV payload from a field of Iowa corn. Left to right: Mark Garrett, KA9SZX; Paul Verhage, KD4STH; and Jim Harper, KCØSHZ.

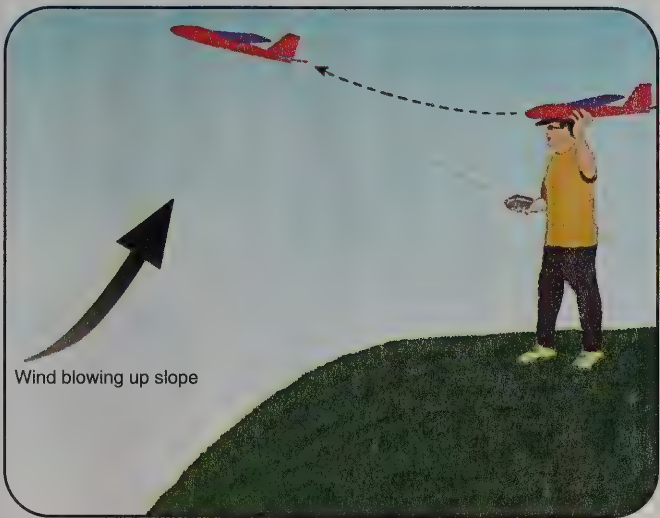
By Del Schier,* K1UHF

Motorless Flight

Perhaps the most enjoyable way to fly is without a motor, whether it is a full-size glider that you can fly in or a model that you fly from the ground. This month's column is a quick overview of RC (radio-control) soaring—how it is done and the necessary equipment.

Gliders are the simplest form of aircraft. They also have many advantages over more complicated types. They are less expensive, easier to build, and more reliable. In general, they also are easier to fly. However, the skill it takes to keep an aircraft such as this in the air without a motor is an endless challenge.

Personally, I find soaring fascinating, a challenge similar to using unusual radio propagation for working DX on VHF and above. You will never be bored with our infinitely changing atmosphere! Both flying and radio propagation are highly dependent on the atmosphere.



The basic slope launch. (Photos courtesy of the author)

Two Forms of Soaring

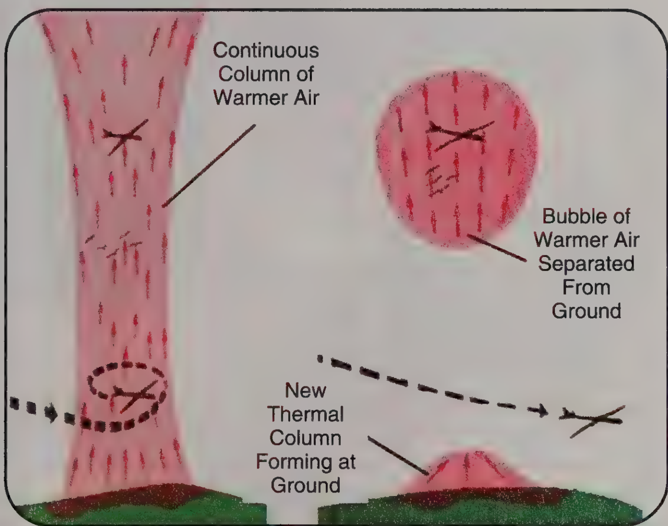
There are two basic forms of soaring— slope soaring and thermal soaring. The term *soaring* refers to keeping a glider aloft longer than it would remain in still air, which is the whole point of flying a glider. Wikipedia® defines soaring as a mode of flight in which height is gained slowly by using air that is moving upwards.

Slope soaring is simply flying in air that is being displaced upwards by some obstacle to the air flow, such as a hill or cliff. When horizontal air flow (wind) hits the side of a hill, it has no way to go but up. If the vertical component of this upward flow exceeds the rate at which the glider descends, you can stay aloft.

It sounds simple, but finding a good place to slope soar requires a variety of factors, such as the wind speed and direction, the shape of the hill and also the amount of turbulence in the air. The ideal hill would have a wide expanse of steep, but not vertical, slope with wind hitting it directly at a perfect 90 degrees. You will never find this perfect slope. Therefore, making do with what you can find is what makes it interesting. It is important that the wind hits the hill without being disturbed by some obstruction in front of the hill. Cliffs along lakes and oceans are ideal, especially if they face the prevailing wind. Depending on where you live, there may or may not be a good place for this type of soaring. I drive to Cape Cod, Massachusetts and have flown at the Marconi site and also at Mt. Greylock, both of which are excellent VHF operating locations.

To fly in slope lift, also known as slope soaring or ridge soaring, you simply fly back and forth in front of the ridge where the lift is best. This sounds simple, but it requires some finesse and an understanding of how the lift is formed by the wind hitting the slope.

The other type of soaring, which is much different and more challenging, is thermal soaring. Thermals are convective updrafts—air that is warmer than the surrounding air and therefore



Pictorial of a column thermal and a bubble.

less dense, lighter, and more buoyant than what naturally rises. Thermals can occur anywhere. Any time the surface of the land is heated by the sun, it causes the air to heat unevenly and produce thermal updrafts when it becomes buoyant enough to lift.

Weather conditions play a major factor in the formation of thermals and are best when the air is convective—that is, colder in temperature and higher in altitude. The worst condition for thermal activity (meaning *no* thermal activity) is when there is a temperature inversion. If you are a VHF DXer and RC glider pilot, there is no conflict of hobbies. You can work VHF openings with temperature inversions and go soaring with the

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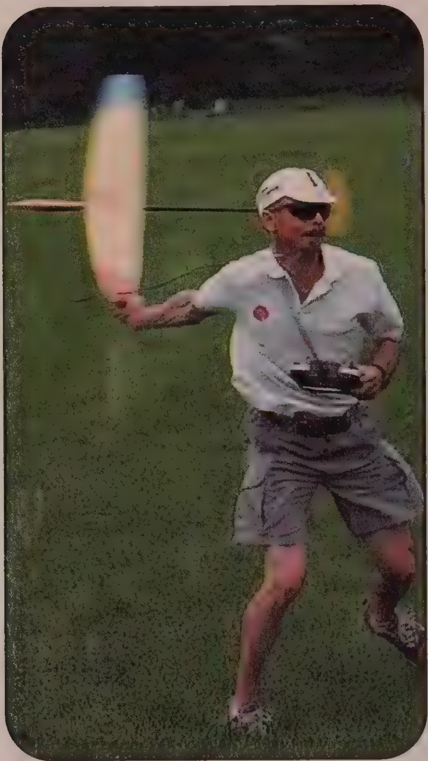


A discus hand launch.

Two-man tow for a competition event.

Launching a big glider on a tow.

opposite weather conditions. I am kind of kidding, but it is true!

Finding thermals can be like searching for the Holy Grail; they are invisible and it almost requires a sixth sense to find them. Actually, a pilot skilled in thermal conditions will have no trouble if the air is unstable and the sun is shining.

Gliders are Solar Powered

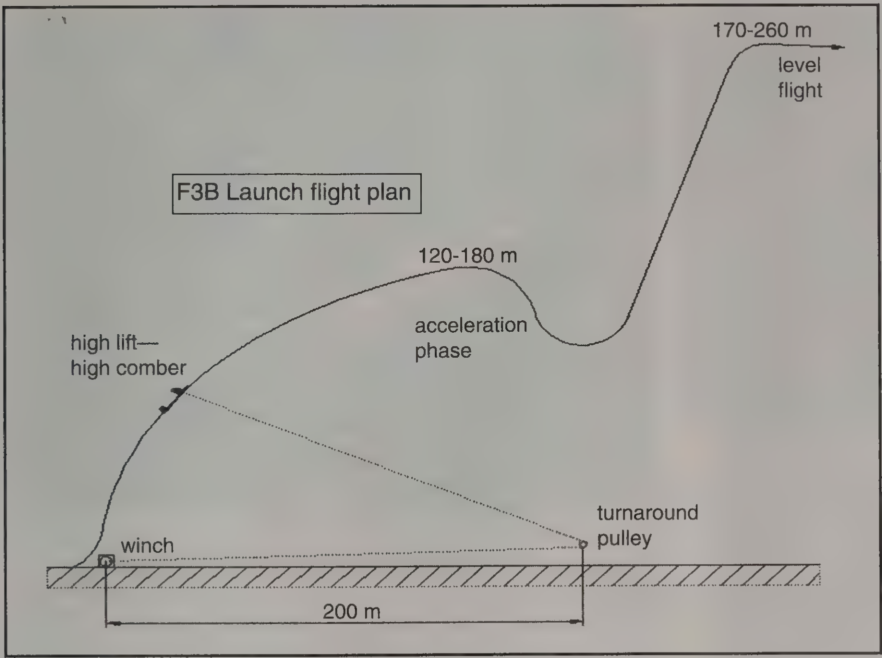
The sun's energy causes air to move and causes convection; therefore, a glider is solar powered. Periodic wind gusts indicate thermal activity, as the air surrounding a lifting body of air moves in to fill the void left by the thermal updraft. The closest thing to visualizing a thermal is to watch a pot of boiling water. Bubbles form on the bottom of the pot and then rise when enough buoyancy is achieved. Thermals on a very convective day are like a rolling boil; the air is lifting vigorously everywhere.

To fly in a thermal you must use all of your senses and carefully monitor the glider. The turbulent boundary layer around the lifting bubble of air will cause the glider to move and shake as it passes through that layer. When the glider hits the thermal, it will pitch up or lift a wing. If the left wing lifts, you turn left into the lift and start circling. You fly in careful circles, adjusting the turn to center on the strongest part of the lift while flying the speed and circle diameter that gives the maximum rate of climb. Any wind causes a thermal to tilt and drift with the wind. Therefore, your glider's circles must also follow the tilt and the thermal's bubble or rising column of air.

Launching the Glider

Okay, how do we launch the glider into the air if we are going fly on the rising air currents? The simplest way is to throw the glider into the lift. For slope soaring it's easy: Just stand on the edge of the hill and throw the glider into the wind. Hand-launching works with thermals, but you have to be lucky and skilled to find a thermal before the glider is back on the ground.

For years model gliders have been launched by throwing them like a javelin. However, more recently hand-launched gliders are thrown like a discus. Special gliders are built to be thrown or launched like a discus. Discus- launch gliders have a throwing peg on one wing tip that allows holding the wing tip and spinning around to impart much more kinetic energy to the glider than a javelin throw. A good javelin launch might put the glider 30 feet in the air, but a discus launch can achieve over 100 feet in altitude. Either way, it is a challenge to throw to the maximum altitude and a bigger challenge to find a thermal before the glider is back on the ground.

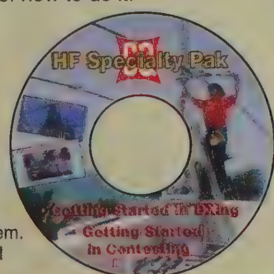


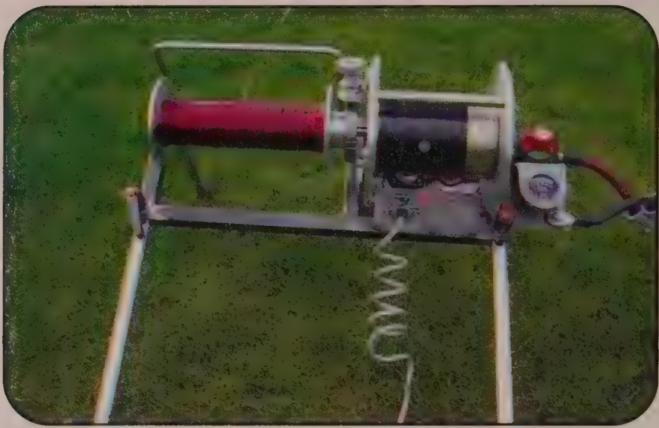
FAI F3B competition-class electric winch system using a car starter motor.

There are many other ways to launch a glider. A bungee launch uses surgical tubing or a bungee cord staked into the ground with a long cord attached to the glider end. The bungee-launch cord is stretched out to the appropriate tension by walking downwind. A ring is attached to the end of the cord and then hooked on a tow hook on the underside of the glider. The glider is released and catapults almost vertically into the air, eventually leveling out at the maximum height possible. This launch has to be done correctly or it can easily end in disaster, as you can well imagine.

Another way similar to the bungee launch is using an electric winch. This is usually a car starter motor with a drum of strong cord that goes several hundred feet to a pulley and back to the pilot and glider. The pilot steps on a switch and takes the tension out of the cord and with just the right timing releases the glider and modulates the power, thereby lofting the glider to several hundred feet in the air. Another way to launch a glider is two men run, pulling the glider into the air with a pulley system. Both the men pulling launch method and the electric winch system are used for FAI[1] (The Fédération Aéronautique Internationale) world-class competitions.

The purists may not like it, but today most sport fliers fly gliders with electric motors. The motor is used only for a few seconds to get to winch altitude and then it is shut off. An electric-launch sailplane has a folding propeller to minimize the





A homebrew winch.

A hollow molded 2-meter fiberglass and carbon Gabby-E, the newest addition to my fleet and another folding prop.

A simple rudder and elevator 2-meter glider, the "Gentle Lady."

A foam electric-launch training glider. Notice the folding prop.

drag. With the incredible efficiency and low weight of a brushless motor and lithium battery, there is very little penalty in performance flying an electric glider. Setting up any kind of bungee or other launch is a project and requires a lot of walking back and forth. Electric launches are simply a matter of having a charged battery and opening the throttle.

There is one more way to launch a sailplane—an aero tow. Just like full-size sailplanes, larger scale RC gliders are towed into the air by a scale tow plane. Of course, the simplest and most challenging way to fly is to just throw your glider into the air.

Varieties of RC Gliders

RC gliders, like all RC airplanes, come in a wide variety of styles. The simplest are rudder and elevator control only. A full-house sailplane has ailerons, flaps, spoilers, elevator and rudder, and perhaps even retractable landing gear and a tow hook. They come in all sizes up to 5-meter wingspans or more.

Model gliders perform better if they are bigger because of aerodynamic effects defined by something called *Reynolds numbers*. Wings are more efficient, and there is less drag and more lift if they are long and skinny (high aspect ratio). The construction of an RC glider might be balsa wood and covering, or foam, with the best construction being hollow molded fiberglass Kevlar™ and carbon fiber.

Finally . . .

Here is a bit of advice for the VHF operator who is also an RC glider enthusiast: Remember to stay home and operate your VHF-and-above station on those days with temperature inversions and fly your plane when there are cumulus clouds.

73, Del, K1UHF

Note

1. Founded in 1905, the FAI is a standard-setting and record-keeping body for aeronautics and astronautics. This includes man-carrying vehicles from ballons to spacecraft and unmanned vehicles such as model aircraft. It is also the international governing body for air sports. *(Courtesy Wikipedia)*

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Computerized T-Hunting with Doppler RDF

Technology in the spy movies of the 1960s and 1970s has always given me a chuckle. The hero often had a sophisticated-looking screen on the dashboard of his sports car. It received transmissions from a "bumper beeper" transmitter on the bad guy's car and displayed his exact location on a moving map as the obligatory chase proceeded through the streets. The real radio-direction-finding (RDF) methods of the time didn't have nearly enough accuracy to pinpoint cars that way, but it made good fiction.

Twenty years ago, Bob Bruninga WB4APR, took the first step toward making this kind of spy tracking a reality when he wrote the Automatic Position Reporting System (APRS). It was an adaptation of a program he had previously written to map the growing network of packet BBS nodes. APRS displays the position and movement of stations that report their latitude and longitude. When inexpensive Global Positioning System (GPS) receivers with serial data output became available, APRS made instantaneous vehicle location practical for almost every ham.

Early GPS sets were insensitive battery hogs with quadrifilar helix antennas pointed toward the sky and single-channel receivers that took many minutes to acquire the Navstar satellites. Position errors with government-imposed "Selective Availability" often approached 300 feet. Today's multi-channel GPS receivers are far more sensitive and lock in much more quickly. With SA turned off and with aid from the new Wide Area Augmentation System, typical accuracy is now 25 feet or better.

In this decade, remote tracking using GPS has become so commonplace that young people can't remember when it didn't exist. GPS controls the movement of fleets of company vehicles and locates cellular callers to 911.[1] Parents can surreptitiously keep track of their teenage drivers almost as easily as the fictional spies of 40 years ago did of the bad guy.[2]

If there were "Thinking Outside the Box" awards, Bob Bruninga, WB4APR, would clearly be a winner. Bob pioneered remote-location technology in the 1980s and developed many novel uses for it. Here he gives an overview of APRS at the Tampa Bay Hamfest in Florida. (All photos and screen captures by Joe Moell, KØOV)

APRS RDF Networking

During the 1990s, WB4APR constantly devised novel applications for APRS, such as tracking high-altitude balloons, marathoners, emergency vehicles, Olympic torch runners, and even the ceremonial 128-mile game ball relay for the annual Army/Navy football game. Besides their coordinates, APRS stations can beacon their own weather data, DX reports, and RDF bearings for display on the screens of all other users within radio range.

Some transmitter hunters envisioned a time in the future when networked APRS triangulation would provide nearly instantaneous location of any signal of interest, including malicious interference, stuck transmitters, and spurious emissions.

At first, all RDF entry was from the keyboard. Stations in strategic locations took accurate bearings relative to true north and typed them in. APRS automatically deleted them after two hours to prevent clutter on the network.

The next goal was to automate the process. The idea was that APRS terminals with Doppler RDF sets[3] would beacon their position and bearings with no manual entry. Unattended and attended base stations would assist mobiles driving to the target on cooperative searches.

At that time, only the relatively expensive Doppler Systems[4] RDF sets had serial bearing data output. Bob modified APRS to accept this format, which provided one-degree resolution. Next came a 3" × 4" interface board designed by Robert Swain, N7LUE (now KA4JSR).[5] It tapped into the 16-LED displays of affordable Doppler sets of the day, such as the Roanoke Doppler[6] and the Dick Smith Doppler[7]. APRS was upgraded to support this data format, but with only 22.5-degree resolution, it left a lot to be desired.

In 1995, the first commercial microprocessor-based Doppler RDF set appeared on the market, manufactured by Agrelo

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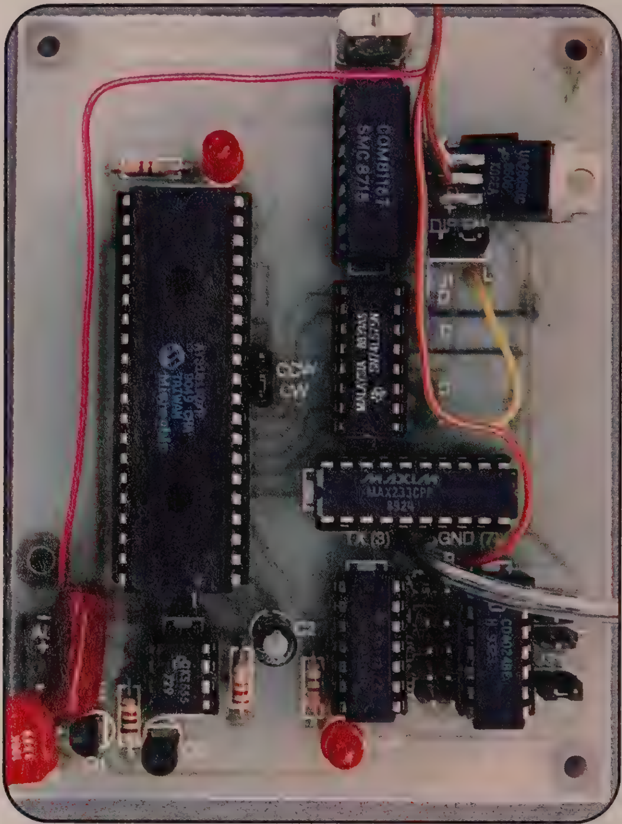


Robert Swain designed this interface to connect classic 16-LED Doppler sets to computers running APRS. This one-of-16 data format is not supported by GPSS.

My original APRS-DOS mobile setup used this laptop to display the rudimentary maps of the time. The packet-relayed bearings from several base and mobile stations (represented by triangles) are converging in an area that is not well-mapped. The solid-line bearings indicate highest quality, while dashed or dotted lines indicate lower quality bearings.

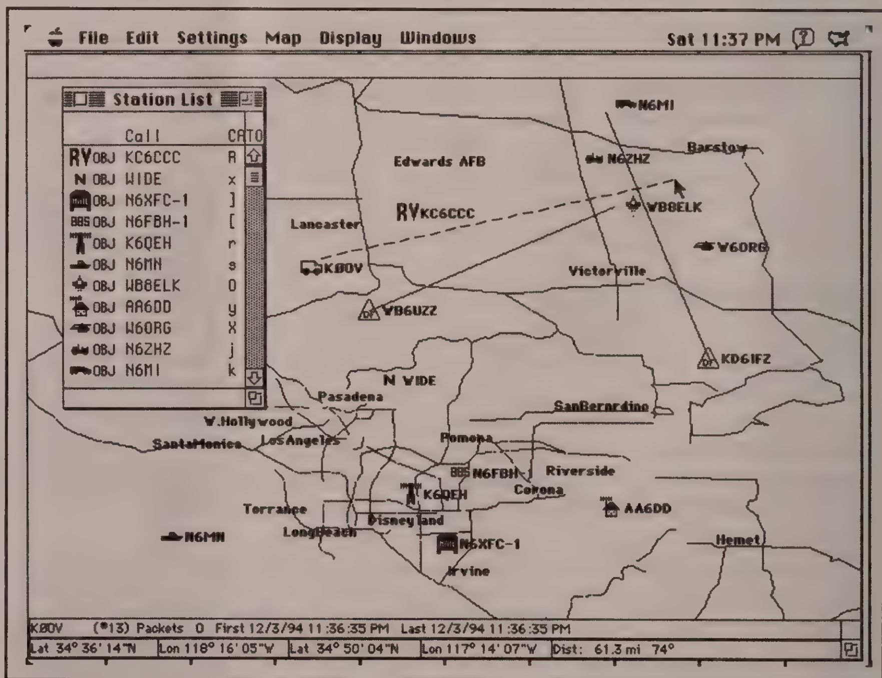
Engineering. Designed with APRS and other tracking networks in mind, the DFjr boasted an improved data-stream format that would support 0.1-degree bearing resolution, although the DFjr's stream was only capable of 1.4-degree resolution. Output bearings were averaged from 96 directional samples and were assigned quality numbers from 0 to 9, based on consistency of the samples.

At about $350 for the plug-and-play display unit and antenna set, the DFjr quickly attracted a large backlog of orders. Unable to fulfill them, Agrelo Engineering went out of business in 1998. Nevertheless, "Agrelo format" became the standard for serial Doppler bearing interfaces.

When WB4APR wrote APRS-DOS in QuickBasic, his biggest problem was the mapping. Commercial digitized map suppliers were insisting on royalties for every copy of every map. Therefore, Bob developed his own system. Anyone with patience could create his or her own maps for APRS, and many did. That was good, because APRS-DOS maps were small files that didn't clog the tiny hard drives of the day.

These simple maps were okay for rudimentary triangulation, but inadequate for street-level mobile navigation. The next step came in 1994, when Keith Sproul, WU2Z, wrote a Think-C version of APRS for 680x0 series Macintosh computers with help from his twin brother Mark, KB2ICI. Including the serial RDF bearing input feature was important to Keith, because he was Senior Technical Advisor to a college amateur radio club that was launching high-altitude balloon packages. He wanted an RDF backup to the onboard GPS telemetry.

MacAPRS took advantage of the mouse, multiple windows, and pull-



MacAPRS graphics were an improvement over those of APRS-DOS. The maps could be zoomed in to show individual streets, but the streets were not named.

down menus of the Macintosh. With an accompanying utility, MacAPRS users could create their own unlabeled street-level maps based on public USGS data. A version of APRS for Windows® by the Sprouls soon followed, with the same maps and automatic RDF features.

Fast Forward to 2007

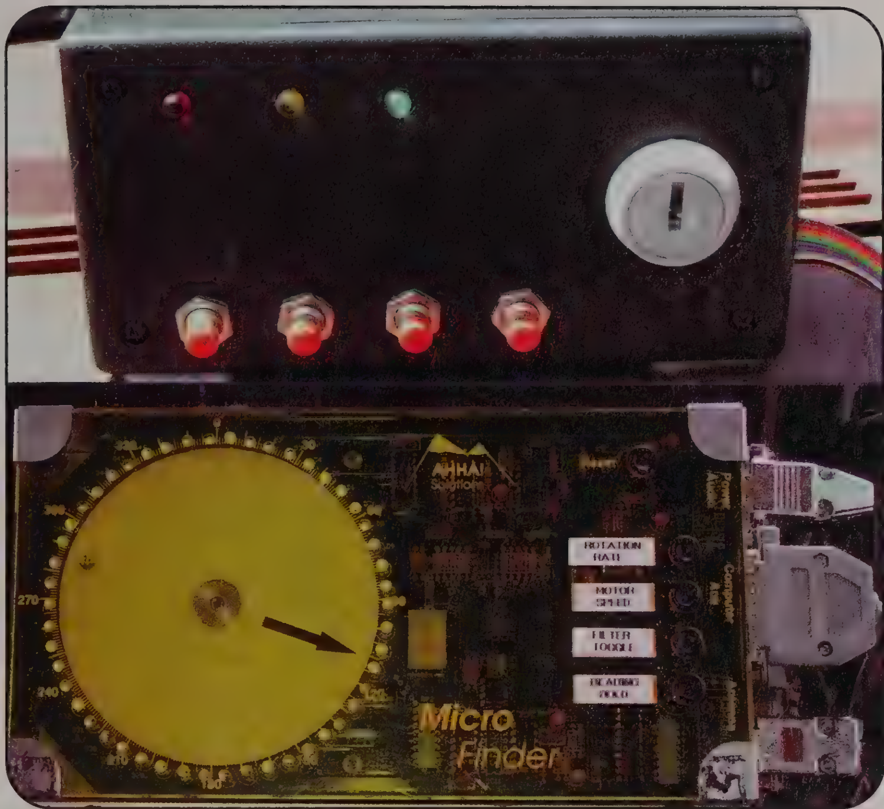
Detailed street-level map data and hard-disk space to store it now are readily available. New versions of APRS such as APRS-SA and Xastir have come along to take the place of APRS-DOS and MacAPRS. They don't include RDF interfaces, probably because there were very few hams who made use of them in the earlier programs.

There were technical problems with hands-off APRS RDF. Many hams couldn't get the Hardware Single Port system working to connect together the GPS, RDF, and packet Terminal Node Controller (TNC). The packet beaconing transmitter often caused QRM to the signal being tracked. It wasn't easy to automatically beacon RDF data only of the signal of interest without also beaconing false bearings of noise or other signals on the RDF frequency.

There were non-technical issues, too. Most mobile T-hunters don't want to divulge their positions and bearings when they are in competition. The APRS on-air network isn't secure, which makes it unsuitable for covert tracking of malicious interference. For balloon tracking, jammer-stalking, and search/rescue missions, when cooperation is important, most users have concluded that it is just as efficient and much more secure to exchange bearings via cell phone.

For almost all the mobile transmitter hunting that I do, precise navigation is more important than bearing networking. Thus, I have turned from APRS to GPSS[8], a navigation program by Robin Lovelock of Sunninghill, UK. Although GPSS was available back when Agrelo Engineering was in business, it was e-mail from two "Homing In" readers that got me thinking about it again.

GPSS is modular and easily adaptable to new features and technologies. Users can draw their own street-level maps or adapt aerial/satellite photos from the Internet, but it's usually easiest to just download the maps at Robin's site. He has them for dozens of countries. I found files of fully labeled street-level maps for 1×1-degree latitude/longitude rectangles throughout the states. Four of them cover all the territory where I do 90 percent of my mobile T-hunting.



There are 50 LEDs in the display ring of the MicroFinder Doppler set by AHHA! Solutions. I built the black box to house additional features that are supported by the firmware, including a heads-up left-right-center indicator and four additional soft-buttons for quick calibration and control of bearing output flow. The keyswitch prevents accidental changing of the calibration.

Like the APRS programs, GPSS must communicate with both the GPS receiver and the RDF set so that bearings are automatically displayed as vectors from vehicle positions along the roads. GPSS is easier to implement than APRS, because there is no TNC interface.

RDF sets with Agrelo-format serial output have features to combine the GPS and RDF data strings onto one RS-232 port at 4800 bps, but models are significantly different from one another. If you are picking a GPS set for use with Doppler RDF, make sure that it outputs NMEA-formatted GPS data over RS-232, not USB. I use the Magellan Gold. Of course the computer must have a RS-232 port, which is getting hard to find in new PCs.

GPSS supports separate computer ports for GPS and RDF, but this may introduce timing problems. Joe Bizzaro, WJ2B, and I recently corresponded about his attempt to use a USB-output GPS set with the DFjr and its RS-232 bearing stream. The differences in port rates led to bearing vectors being displayed from the wrong road positions. GPSS has provisions to delay RDF bearing data to accommodate delays within GPS sets, but not the other way around. WJ2B solved the problem by changing to a RS-232 output GPS set and using the data combining feature within the DFjr.

The DFjr has a GPS data input and intersperses GPS data with bearing data on its serial output. Unfortunately, the firmware is fixed such that bearings come out more than once per second and GPS data comes out every five seconds at the fastest. That's too much RDF data and not enough GPS data, so the PC screen gets cluttered with bearings. A partial solution is to set the GPSS-DF configuration file to require several tenths of a mile travel between accepted bearings. A hardware work-around would be to put a switch in the cable from DFjr to computer, to control the bearing flow. A SPDT switch is necessary, because when bearings are off, the

computer input must be switched directly to the GPS receiver for navigation.

Although I own a DFjr, I prefer the MicroFinder Doppler set from AHHA! Solutions, which has better GPS-DF combining. It passes almost all of the NMEA data for the most accurate vehicle tracking. Bearings in Agrelo format are interspersed at a rate programmed by the user, from every second to every 50 minutes. You can set a panel pushbutton to toggle the bearing stream on and off so that it's only on when a signal of interest is being tracked. You can program another button to send just one bearing when the stream is off, which is perfect for that moment when you crest a hill and the bearing is most free of multipath.

GPSS speaks periodically to tell where you are and the direction you're traveling. This voice output is handy when you are alone—just like having a navigator talking to you. If you already have a navigator or don't want the distraction, you can command the voice to stop the updates and only give critical messages. Conversely, you can give commands to GPSS by voice instead of keyboard if your computer supports voice recognition.

Too Many Destinations

If you allow it, GPSS will triangulate all your RDF bearings and display the most recent bearing intersection as a destination. Robin's voice will tell how far away you are from this destination and the relative direction to it, such as "Destination 3.5 miles at your 4 o'clock." With the configuration file, you can instruct GPSS not to triangulate bearings less than a given number of degrees apart and to suppress triangulated destinations more than a given distance away.

The automatic triangulation feature sounds great in theory, but it's practical only when you present GPSS a few carefully chosen bearings. If you just feed in the constant bearing stream from your Doppler, the normal variations in bearings due to vehicle motion and nearby signal reflections will result in close-in triangulations from successive bearings about 50 percent of the time. You will constantly hear a voice telling you that you're less than a mile away from the target, even if you're not. The screen maps will keep changing to display these bogus destinations.

I am now discussing ideas for improvements to the triangulation feature with Robin and some other GPSS RDF users. Perhaps a keyboard command to perform triangulation only when it is wanted would be a good fix. Watch for any changes on the RDF page of Robin's site. Meanwhile, I use an undocumented feature in the configuration file[9] to suppress all automatic triangulation when I'm not closing in.

In the close-up screen shot is a demonstration of how GPSS helps me circle in on the target. Proceeding east on Dorothy Lane, the bearing is to the left, so a turn north onto State College Boulevard seems appropriate. However, that isn't the shortest way to the transmitter. GPSS draws bearings as I correct by turning east onto Yorba Linda Boulevard, go under the 57 freeway, turn south on Placentia Avenue, and west on Nutwood Avenue. From all the bearing crosses, it's clear at that point that the target is in the parking lot just west of Campus Drive, which is where I go. The most recent bearing is white. Previous bearings are shades of yellow, the darkest are oldest.

GPSS has additional navigation features, such as an "instrument panel." It is capable of auto-routing and turn-by-turn directions to destinations, but this requires much more detailed mapping than supplied on Robin's site. I already have a Garmin StreetPilot® on the dashboard to give directions, so I use that for vehicle navigation and let GPSS concentrate on RDF tasks.

GPSS may be used for non-commercial purposes at no charge. It is fully functional once downloaded and installed, but an annoying "This software is unregistered!" banner appears regularly. Robin will provide a free banner-killing one-computer key code, good for six months and probably renewable, if you answer his online questionnaire. You have the option of buying a permanent key code, linked to your name and good on any PC, for 20 GBP (about US$40).

After more than a decade of support, Robin remains very responsive to his GPSS users. I discovered that GPSS wouldn't respond to tenth-degree resolution bearing data from the MicroFinder, which apparently had not been a problem on slower computers in the past. Robin found the bug, fixed it, and posted an updated GPSS version within 24 hours.

MicroFinder detects second-harmonic level in the induced Doppler audio tone to determine quality of bearings, which is more effective than the DFjr's statistical method. Low-quality bearings are suppressed from showing on the LED ring by two levels of optional digital filtering. You can also program in a minimum-quality threshold for bearings to be sent out to GPSS (e.g., only 7 or higher). MicroFinder was supplied as a kit without antennas and antenna switcher, but it supports a wide variety of antenna systems from three to eight elements, including my wide-range Roanoke switcher.[10] If you want one today, you will have to scour the flea markets and auction sites.

Last Call for USA's 2007 ARDF Championships

As this issue arrives in your mailbox, it's not too late to register for the Seventh USA Championships of Amateur Radio Direction Finding (ARDF), which are scheduled for September 14 through 16 at South Lake Tahoe, in the Sierra Mountains near the border between California and Nevada. Beginners and experts at on-foot radio-orienteering will test their skills and learn from one another. Some may win positions on ARDF Team USA for the next World Championships in 2008.

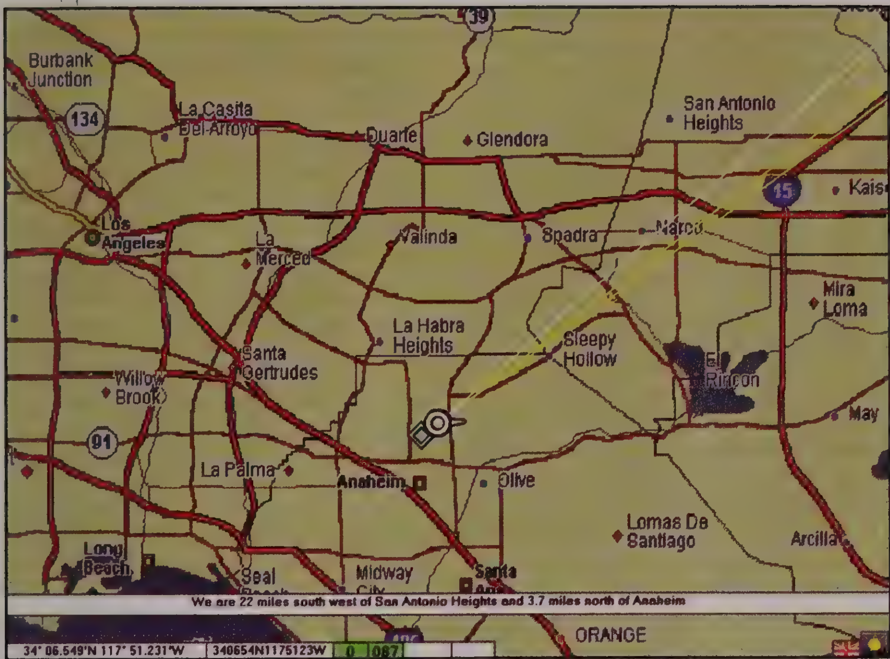
Santa Barbara Amateur Radio Club and Los Angeles Orienteering Club are joining together to present the 2007 USA Championships. As in recent odd-numbered years, our national championships are being combined with the ARDF championships for International Amateur Radio Union (IARU) Region 2, encompassing North and South America.

The 2-meter and 80-meter ARDF courses will be open to all, beginner and expert alike. Event headquarters will be at Camp Concord in the El Dorado National Forest. An inexpensive package including two nights of lodging in the rustic cabins and five meals is being offered to event registrants. There are other lodging and dining options nearby.

National ARDF Championships are for individuals only. No teaming or assistance on the course is permitted. Participants are divided into five age categories for males and four age categories for females in accordance with standard IARU rules. Medals for first, second, and third place will be awarded in each category.

As this issue goes to press, plans for the championships are going ahead, despite the June wildfires in the South Lake Tahoe area. The latest information and registration forms, plus photos of accommodations at Camp Concord, can be found at <www.homingin.com>. There you will also find lots more about the international sport of ARDF.

Joe Moell, KØOV
ARRL ARDF Coordinator



As I drive away from the hilltop starting point on a transmitter hunt, this wide-area GPSS map helps me determine where I might be headed. Because there are normal variations in successive Doppler bearings, I have turned off automatic triangulation to keep bogus destinations from being displayed.

They are no longer sold new in kit form, but a working used one would be a worthwhile purchase.

Three currently available Doppler set designs provide bearing data in Agrelo format: PicoDopp by Bob Simmons, WB6EYV[11], DSP-RDF by Dan Welch, W6DFW[12], and the Montreal Doppler 3v2 by Jacques Brodeur, VE2EMM[13]. Each of them has provisions to combine

Close-in GPSS triangulation to a hidden transmitter in a university parking lot. The trail of closely spaced white-dot "breadcrumbs" shows the most recent vehicle movement. The large circle is the current vehicle position. The "Anaheim" label is a USGS mapping error, because this institution is actually in Fullerton, just north of Anaheim.

RDF and GPS data onto one 4800-bps RS-232 port for GPSS, but there are differences in how the GPS data is handled within the RDF sets. Watch for more on these sets in future "Homing In" columns.

GPSS automatically adds the relative RDF bearing to the vehicle heading to display bearings relative to true north. If your RDF set outputs a true-north-referenced bearing already, you can tweak GPSS to accept that.

Safety First

When you experiment with mobile computer mapping and tracking, keep safety in mind at all times. Have solid mounts for your computer, GPS, and RDF gear so they can't fly about. Minimize distractions and pay full attention to the road while driving. Get a helper to handle the computer and RDF gear when you drive, or get someone else to drive so you can concentrate on the RDF task. Carefully check your cable wiring to prevent expensive damage to RS-232 hardware.

GPSS can be operated in a simulation mode without serial GPS and RDF data input. RDF station locations are entered by mouse right-click and true bearings are entered by keyboard. In this mode, a network of base stations could gather bearings from one another and triangulate them to estimate the location of an unknown signal. Bear in mind, however, that mapping programs such as GPSS and APRS assume a flat Earth. This won't cause significant triangulation errors on local VHF T-Hunts, but it won't do for pinpointing signal sources on the HF bands from locations that are hundreds of miles apart. That would require an advanced program that performs spherical triangulation.

If you are using a computer to automatically display bearings when mobile, whether with a Doppler or another type of RDF setup, I would like to hear from you. Let me know how well your system works, what you like, and what improvements you would like. Also, if you have not already done so, be sure to send me a report of your activities during the CQ Worldwide Foxhunting Weekend last May. Happy hunting! 73, Joe, KØOV

Notes

1. Verizon and Sprint mobile networks use GPS receivers in users' phones to report location when they call 911. More on enhanced 911 locating systems for wireless networks is in "Homing In" in the Winter 2007 issue of *CQ VHF*.

2. <http://www.gpsglobalstar.com/sub_main.php?selection=whatdt>

3. See "Homing In" in the Spring 2004 issue of *CQ VHF* for tips on optimizing performance of the DFjr and other Doppler RDF sets.

4. <http://www.dopsys.com/>

5. Moell, Joe, "HOMING IN: APRS Puts Doppler Bearings on the Map," *73 Magazine*, August 1995.

6. Complete plans in "Transmitter Hunting—Radio Direction Finding Simplified" by Moell and Curlee. Information on this book and Roanoke Doppler antenna system improvements are at <www.homingin.com>.

7. Information on the Dick Smith RDF set and improvements are at <http://members.aol.com/homingin/DSEfix.html>

8. <http://www.gpss.tripoduk.com/>

9. Set the first line of GPSSDF.CFG file to -9999.0.

10. <http://members.aol.com/homingin/newdopant2.html>

11. <http://www.silcom.com/~pelican2/PicoDopp/PICODOPP.htm>

12. <http://www.byonics.com/dsp-rdf/>

13.<http://www.qsl.net/ve2emm/pic-projects/doppler3/doppler3-e.html>

QUARTERLY CALENDAR OF EVENTS

Current Contests

August: There are two important contests this month. The **ARRL UHF and Above Contest** is scheduled for August 4–5. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is August 18–19.

September: The **ARRL September VHF QSO Party** is September 8–10. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 15–16. The **ARRL 2304 MHz and Above EME Contest** is September 29–30. The **144 MHz Fall Sprint** is September 17, 7 PM to 11 PM local time. The **222 MHz Fall Sprint** is September 25, 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 3, 7 PM to 11 PM local time. The **Microwave (902 MHz and above) Fall Sprint** is October 13, 6 AM to 12 PM local time. Please note the time change from last year. The **ARRL 50 MHz to 1296 MHz EME Contest** is October 27–28. The Delaware Valley VHF FM Simplex Sprint Contest is October 21, 10 AM to 2 PM local time. For more information see the following URL: <http://www.harcnet.org/contest.htm>. The **50 MHz Fall Sprint** is October 20, 2300 UTC to October 21, 0300 UTC.

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 24–25.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or the URL <http://www.arrl.org>. For Fall Sprint contest rules, see the Southeast VHF Society URL: <http://www.svhfs.org>.

Current Conferences & Conventions

September: The 2007 **TAPR/ARRL Digital Communications Conference** will be held September 28–30 in Hartford, Connecticut, at the DoubleTree Hotel in Windsor Locks. For more information, go to: <http://www.tapr.org/>.

October: The 2007 **Microwave Update** conference is to be hosted by the Packrats and will be held October 18–20, in Philadelphia, Pennsylvania at the Inn at Valley Forge. For further information, please check the Microwave Update website: <http://www.microwaveupdate.org>.

The 2007 **AMSAT-NA Space Symposium and Annual Meeting** is to be held October 25–28 in Pittsburgh, Pennsylvania at the Pittsburgh Airport Marriott Hotel. For more information, see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat-new/symposium/2007/index.php>.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

Aug. 3	Moon Perigee
Aug. 5	Last Quarter Moon; Moderate EME conditions
Aug. 12	New Moon and *Perseids* Meteor Shower Peak; Good EME conditions
Aug. 19	Moon Apogee; Poor EME conditions.
Aug. 20	First Quarter Moon
Aug. 26	Moderate EME conditions
Aug. 28	Full Moon and Total Lunar Eclipse visible throughout most of eastern Asia, Australia, the Pacific Ocean, and the Americas
Aug. 31	Moon Perigee
Sept. 4	Last Quarter Moon
Sept. 11	New Moon and Partial Solar Eclipse visible throughout most of central and southern South America
Sept. 15	Moon Apogee
Sept. 19	First Quarter Moon
Sept. 23	Fall Equinox
Sept. 26	Full Moon
Sept. 28	Moon Perigee
Oct. 3	Last Quarter Moon
Oct. 11	New Moon
Oct. 13	Moon Apogee
Oct. 19	First Quarter Moon
Oct. 20	*Orionids* Meteor Shower Peak
Oct. 26	Full Moon and Moon Perigee
Nov. 1	Last Quarter Moon
Nov. 9	New Moon and Moon Apogee
Nov. 17	First Quarter Moon and *Leonids* Meteor Shower Peak
Nov. 24	Full Moon and Moon Perigee

—EME conditions courtesy W5LUU.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, e-mail, etc., please contact the person listed with the announcement. The following organizations or conference organizers have announced a call for papers for forthcoming events:

ARRL and TAPR Digital Communications Conference: Technical papers are solicited for presentation at the 26th Annual ARRL and TAPR Digital Communications Conference to be held September 28–30, 2007 in Hartford, Connecticut. These papers will also be published in the conference *Proceedings* (you do *not* need to attend the conference to have your paper included in the *Proceedings*). The submission deadline is July 31, 2007. Please send papers to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111, or you can make your submission via e-mail to: <maty@arrl.org>. Papers will be published exactly as submitted and authors will retain all rights.

AMSAT-NA 2007 Space Symposium: Technical papers are solicited for the 2007 AMSAT Space Symposium and Annual Meeting to be held October 25–28 in Pittsburgh, Pennsylvania. Proposals for papers, symposium presentations, and poster presentations are invited on any topic of interest to the amateur satellite program. An emphasis for this year is educational outreach to middle and high school students. In particular, papers on the following topics are solicited: Students & Education, ARISS, AO-51, P3E, Eagle, and other satellite-related topics,

Camera-ready copy on paper or in electronic form is due by September 1 for inclusion in the printed symposium *Proceedings*. Papers received after this date will not be included in the printed *Proceedings.*

Abstracts and papers should be sent to: Daniel Schultz, N8FGV, via e-mail: <n8fgv @amsat.org>.

Microwave Update: A call for papers has been issue for the 2007 Microwave Update. If you are interested in submitting a paper for publication in the *Proceedings,* then please submit your papers, articles, and abstracts to W2PED at <pdrexler@hotmail.com> or to N2UO at <lu6dw@yahoo.com> in MSWord or as a PDF by August 15, 2007. Diagrams, photographs, and illustrations should be in black and white. Hard copies may be mailed to Paul E. Drexler, 28 West Squan Road, Clarksburg, NJ 08510.

Current Meteor Showers

August: Beginning around July 17 and lasting until approximately August 24, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 0500–0730 UTC on August 13. A possible tertiary peak may occur around 1500 UTC. Amateur radio communications data could confirm or detect otherwise unobserved maxima. The *κ-Cygnids* meteor shower is expected to peak on August 18.

October: The *Draconids* is predicted to peak somewhere around 2030 UTC on October 8, then again around 0910 UTC on October 9. The *Orionids* is predicted to peak on October 21.

November: The *Leonids* is predicted to peak around 0250 UTC on November 18. However, unlike recent showers, this year's peak may go largely unnoticed.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's propagation column beginning on page 78. Also visit the International Meteor Organization's website: <http://www.imo.net/calendar/2007/>.

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Satellite Station Alternatives

Since my last column, I have participated in three major amateur radio events: the Dayton Hamvention®, Ham-Com, and Field Day. This year at the Hamvention® and Ham-Com I had the opportunity to be in charge of real-time demonstrations on the amateur radio satellites. In the past I have usually done these demonstrations utilizing only the FM satellites or given a "receive only" demo on the SSB/CW birds. Working with Drew Glasbrenner, KO4MA, last year inspired me to include full demonstrations of the SSB/CW birds.

This year I was determined to find a way to do full demos on all of the birds. In addition to requiring multi-mode transceiver capability, SSB/CW demos require more "hands-on" operation to do the precise tuning required to compensate for Doppler and match up your uplink and downlink while still keeping the antenna pointed, etc. The RF environment at hamfests and major conventions represents a challenge as well. In this column I will address some solutions to these demo problems and expand into Field Day with a special mode this year.

Multi-mode Satellite Demonstrations

Demos on the FM birds are usually done with little more than a dual-band HT and an Arrow antenna or its equivalent. Only one uplink-downlink pair is used per transponder, and Doppler tuning in 5 -kHz steps of the higher frequency is adequate for the mode V/U and U/V birds. A full-duplex capability is highly desirable so that you know for sure when you are "making the bird," but it is not absolutely necessary. One hand can be used to control the antenna and the other hand the channelized FM radio.

On the SSB/CW birds, full-duplex operation is absolutely essential, and precise tuning of both the uplink and downlink is necessary to locate the station you wish to talk to, match up the uplink to the downlink, and continue to correct for Doppler. This normally requires two independent radios, since most full-capability satellite radios are usually a bit cumbersome for a portable environment. All of this must be done while keeping the antenna(s) pointed at the bird. Most people come up at least "one hand short" to do all of this without some extra help.

Handheld multi-mode receivers such as the ICOM IC-R20, Yaesu VR-500, and Kenwood TH-F6A are available; however, these radios suffer, to varying degrees, from poor sensitivity, wide-open front ends, and marginal detectors. Some of these problems can be tolerated in a benign RF environment, but not at Dayton. None of the current handheld equipment has a SSB/CW transmit capability. The best compromise I have found is the Yaesu FT-817 Back-Pack Radio. At least one of these is necessary for the transmit capability. The FT-817 can be paired with one of the other receivers mentioned above, or better yet, with another FT-817. Many other combinations are also possible with larger, more powerful radios, but for the purpose of this discussion I have chosen two FT-817s as the smallest combination of radios that will provide acceptable uplink and downlink performance to do the job.

W5IU at the Dayton Hamvention® demo area working AO-51 FM. The WA5VJB Cheap LEO Antennas and W5IU Cheap AZ-EL Positioner are in the background. (Photo courtesy of Bill Reischl, KBØAZB)

Two possibilities have been explored for the antenna control problem. First, assign the task to another person. Second, place the antenna(s) on an AZ-EL positioner so that the antenna(s) do not have to be held constantly—only updated periodically. Both methods work, and the second method works better if a second person is assigned that task as well.

At both Dayton and Ham-Com the second method was used most of the time on the SSB/CW birds and was implemented with two WA5VJB "Cheap LEO Antennas" mounted on a W5IU "Cheap AZ-EL Positioner." These are described in the

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e-mail: <w5iu@swbell.net>

The Cheap LEO Antennas and Cheap AZ-EL Positioner.

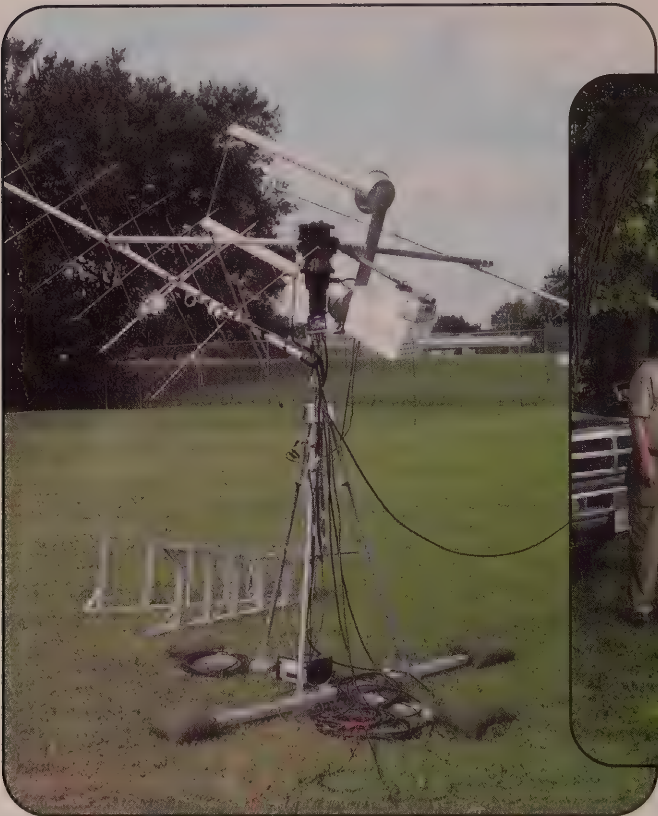
Summer 2006 and Winter 2005 issues of *CQ VHF* magazine, respectively.

FM demos were planned for AO-51, SO-50, and AO-27. However, only the AO-51 demos were actually done due to time constraints. Successful SSB/CW demos were done on VO-52 and AO-07. At one point we actually had a "roundtable" going on VO-52. All of this was done with the FT-817s "barefoot" at 5 watts maximum.

Field Day and AO-51 Mode L/U

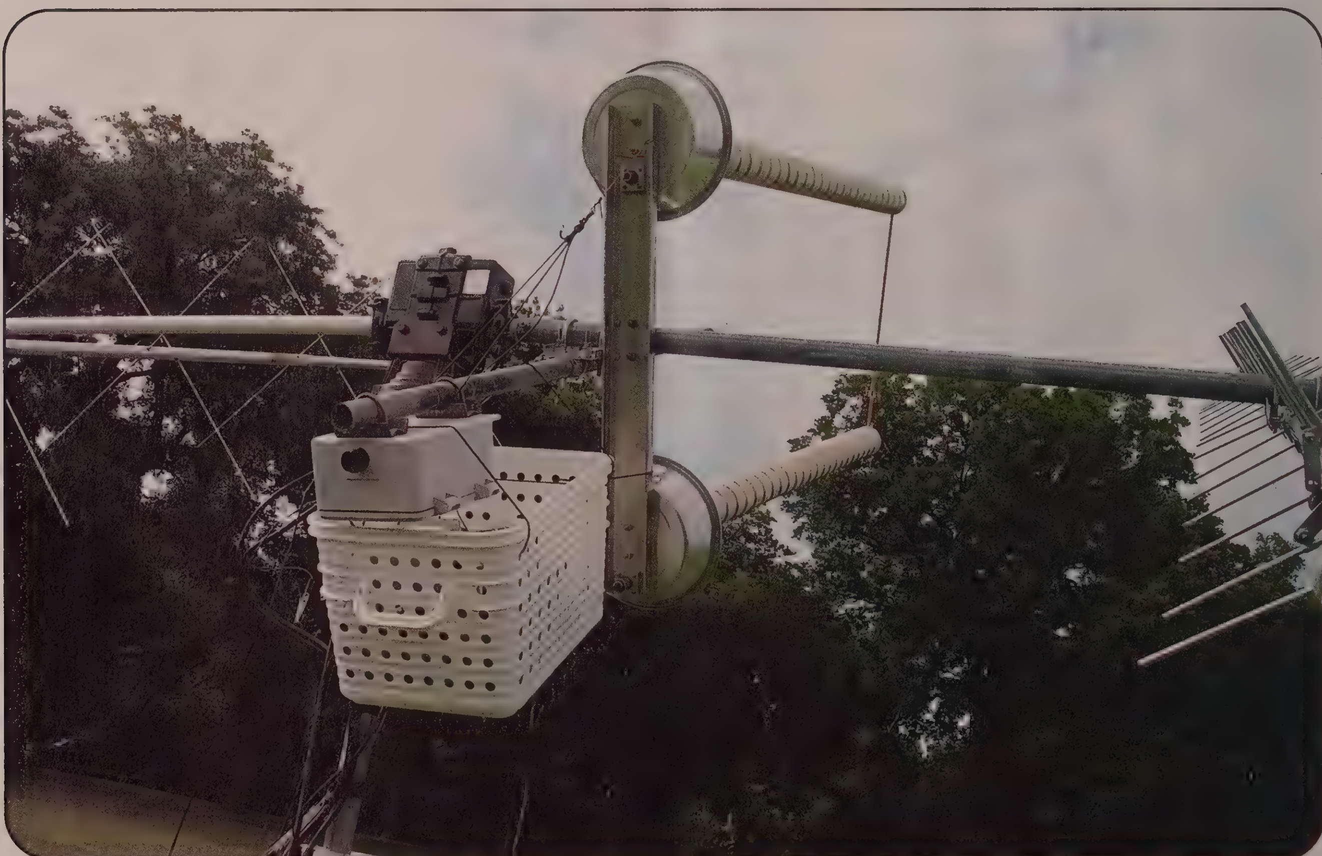
This year the AO-51 Operations Team decided to run both transponders simultaneously on AO-51 for Field Day. One ran

The L-Band transverter and power-amplifier chain.



The W5IU Field Day satellite array.

The Lockheed Martin Recreation Association Radio Club members present at Field Day teardown. (Photo courtesy of Bill Penny, WM5U)



Looking up the satellite array.

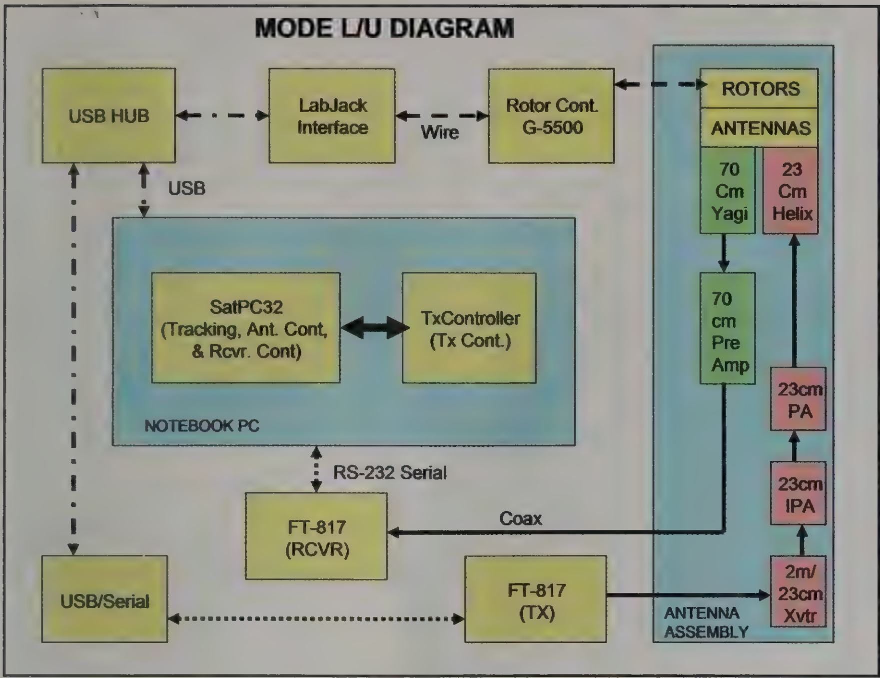


Figure 1. The Mode L/U diagram.

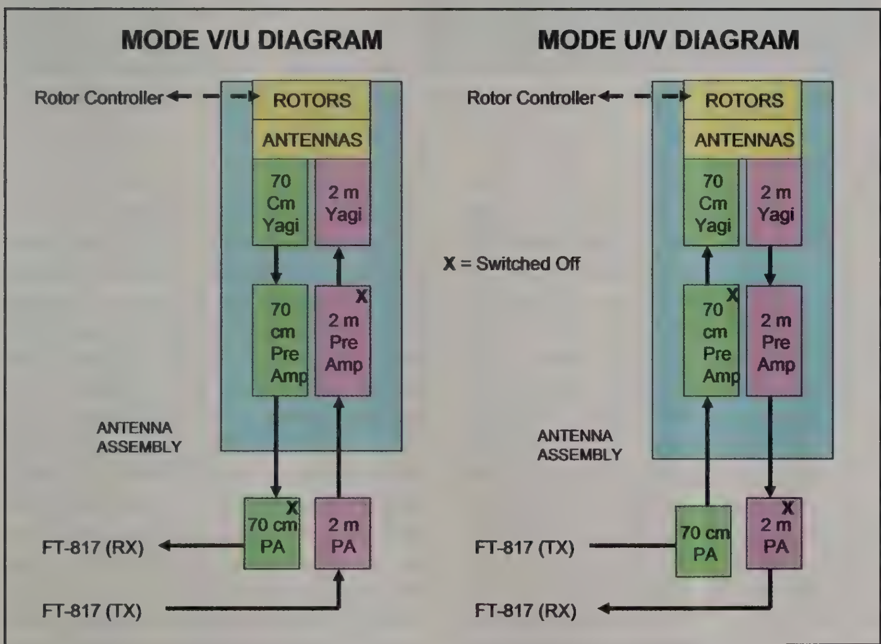


Figure 2. Alternate hookups for Modes V/U and U/V.

in the normal Mode V/U FM configuration and the other one was configured for Mode L/U FM. Mode L/U was the "spark" I needed to get going and try something new.

I decided to combine technology from the old AO-10 and AO-13 Mode L days with newer software and radio technology of today.The old technology consisted of the usual Hy-Gain Satellite Pack antennas for 2 meters and 70 cm supplemented by a WD4FAB 28-turn helix from the 1992 (and later) *ARRL Handbook.* One year I built a set of these for use on AO-13 at W1AW/5 in Arlington, Texas during the ARRL National Convention. Only one of these helix antennas was driven, although two of the original four were mounted on the positioner. RF equipment from the AO-10 Mode L days consisted of an SSB Electronics LSM-24 satellite-transmitter-mixer, an SSB Electronics PA-2310 linear power amplifier, and a Down East Microwave power amplifier. This mixer–power-amplifier chain (mounted in the basket on the back of the helix) provided approximately 20 watts of power to the helix when driven by 1 watt from one of the FT-817s. This combination provided an excellent signal into AO-51.

The newer technology consisted of the two FT-817s (idea borrowed from the demos) and an old Dell notebook running SatPC32 and TxController software. TxController is a program included with SatPC32 that permits control of a separate transmitter while SatPC32 controls a separate receiver, antenna rotors, full Doppler correction, and all of the usual graphical support expected these days. Due to port limitations on the Dell notebook, it was supplemented by a four-port USB hub and one USB to RS-232 serial adapter. Antenna control was provided through a LabJack and LabJack piggyback interface combination from one of the USB ports to the Yaesu G-5500 rotors. Diagrams of this entire hookup are provided. Figure 1 is the Mode L/U diagram; Figure 2 is the alternate hookups for Modes V/U and U/V.

Getting this set up and working required some attention to detail, but the results were worth it. Full Doppler-correction radio control along with automatic antenna control was great. In addition to both modes of AO-51, we also worked VO-52 and AO-27. We heard, but did not work, SO-50 and AO-07 due to cockpit problems. We also missed the first good AO-51 pass for the same reasons. The setup was new to everyone and changed for each bird. Next year these problems will be solved by training, check lists, and a more reliable power source.

Summary

Hamfests and Field Day are great fun, but they also can be very challenging. The FM birds are quite controversial on Field Day due to single-channel operation and the FM capture effect. We desperately need a new HEO (High Earth Orbit) bird. To this end, don't forget to support the AMSATs of the world in their efforts to build and launch new and challenging HEO satellites. Look for P3-E in late 2008 and Eagle after that. Good progress is being made with both of these programs, but they really do need your support.

73 de Keith, W5IU

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

Following Suit

On September 8, 2005, SuitSat (AMSAT OSCAR 54) started its long, desolate journey. (NASA photo)

No amateur satellite has captured the public imagination quite like SuitSat, the discarded Russian space suit that was tossed overboard from the ISS (International Space Station) on September 8, 2005, stuffed full of ham radio equipment and dirty laundry. Proposed by Sergey Samburov, RV3DR, at the 2004 AMSAT Space Symposium near Washington, DC, this innovative project came together in a record 11 months and stands out as one of AMSAT's greatest educational successes despite technical malfunctions that made the suit's 2-meter beacon almost impossible to copy, except by the best equipped high-end ham stations. Nevertheless, students around the world were galvanized by an image evocative of a stranded cosmonaut (see Photo 1), giving amateur radio in general, and the ham satellite community in particular, an unprecedented foot in the classroom door.

Not ones to sit on their laurels, Sergey, Lou McFaddin, W5DID, Frank Bauer, KA3HDO, and their ARISS (Amateur Radio on the International Space Station) team started right in planning a sequel. As this column is being written, SuitSat2 is rapidly taking shape in a handful of laboratories and classrooms scattered around the U.S. However, unlike his predecessor, when this cosmonaut gets the boot, he should not whisper, but roar.

No one knows exactly why the original SuitSat's signals on Earth were several S-units weaker than planned. Speculation centers on malfunctions in the transmitter itself, the antenna, and the coax that connected the two. Nevertheless, significant upgrades are planned this time around, involving more transmitter power, better coax, a new antenna design, a completely different power system (more about that later), and the use of SDR (Software Defined Radio) technology for the first time in an amateur radio satellite. In short, this ain't your father's spacesuit.

The first SuitSat carried into space messages from students around the world. Some of these were the spoken words of greeting, stored in digital memory and transmitted from orbit. Others were essays and pictures contributed by students to a CD-ROM attached to the suit's chest. Unlike the golden records carried into space aboard the NASA Voyager interplanetary spacecraft three decades earlier, this disk was never intended to be recovered and studied by intelligent extraterrestrials. Rather, it was our own terrestrial students who were given the opportunity to contemplate the kinds of messages they would most like to send off into space.

Looking beyond the first SuitSat, the successor spacecraft will carry into space not just student messages, but also student hardware and software. Much of the circuit fabrication and testing is being carried out in an Software Defined Radio course by a group of electronic engineering students at The College of New Jersey in Trenton (see Photo 2). Under the leadership of adjunct faculty members Frank Brickle, AB2KT, and Bob McGwier, N4HY, these undergraduates are gaining experience in producing real spaceflight-qualified hardware. What better motivator can there be for tomorrow's leaders of technology? When the suit gets the boot, I'm sure they will be among the proudest youngsters on planet Earth.

"Working with these kids has been one of the most enjoyable things I've done in quite awhile," writes instructor Frank Brickle, AB2KT, of his students. "They seem genuinely turned on by walking the tightrope without a net as far as SuitSat is concerned. We all will be doing a very good thing if we can continue to involve these kids, and more like them, in future AMSAT projects."

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At The College of New Jersey in Trenton, undergraduate Electronics Engineering students work on the hardware and software for SuitSat2. AMSAT members and faculty mentors Frank Brickle, AB2KT, and Bob McGwier, N4HY, stand at the back. (N4HY photo)

Frank emphasizes that the complexity of his students' project is not to be underestimated. "Since they're working with what is essentially the orbital design, there is nothing in the way of diagnostic hardware or software, which is why I described them as walking a tightrope without a net. Furthermore, given the complexity of what the SDR/SDX in SuitSat2 will be required to provide, the applications will need to run in an unprecedented software environment—preemptive multitasking under freeRTOS (an open-source real-time operating system). What the course comes down to, then, is giving them a little verbal swimming instruction and then tossing them straight into the ocean. Rather than being intimidated, they all seem to be relishing the challenge and meeting it with obvious enthusiasm, just the sort of attitude I have learned to expect during my association with AMSAT. Couldn't be a better match."

The first SuitSat burned up in the Earth's atmosphere just six months after orbital insertion, successfully completing its brief mission to boldly go where no suit had gone before. (As a teacher, I can't help but add, "to boldly split where no infinitive has split before.") SuitSat2 will follow in its footsteps, which means its mission too will be brief. However, because it carries panels of photovoltaic solar cells, and a sophisticated battery charge regulator, this latest suit should transmit for the majority of its orbital lifetime, unlike its predecessor, whose (nonrechargeable) batteries expired after just a couple of weeks.

The power system is one area of focus for The College of New Jersey engineering students. Frank Brickle says, "In talking outside of class, a number of them have expressed real interest in power. It's not a subject covered anywhere in their curriculum. The biggest surprise about them as a group is how interested they are in taking a new approach to very basic, fundamental kinds of engineering issues, and not necessarily the trendy, flashy topics. This is an unexpected source of optimism, for me anyway."

Given the second suit's improved power system, we hope numerous students, in classrooms widely scattered across our globe, will have the opportunity for multiple receptions and ongoing experiments. The more youngsters who can hear SuitSat2's digitally synthesized voice, the more future space technologists we can claim credit for cranking out. Isn't that what AMSAT education is all about?

However, whether they hear a peep from SuitSat2's transmitter or not, I expect thousands of students will be captivated forever by the image of the lonely astronaut, spinning away into the black void of space. If that isn't an educational message, what is? 73, Paul, N6TX

By Bob Witte,* KØNR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

FM VHF at Dayton 2007

After several years of not being able to attend the Dayton Hamvention®, this year my personal and work schedules aligned to allow my attendance at the world's largest ham radio convention. I was really looking forward to getting back to Dayton, and I wasn't disappointed. In this column, we'll take a look at Dayton activities with a FM VHF emphasis.

New Radios

Dayton is a great place for radio equipment manufacturers to show off their latest products. In particular, there were a number of new dual-band FM 146-MHz/ 440-MHz transceivers, a popular type of rig for *utility-mode* ham radio. The ham equipment manufacturers are always looking for ways to differentiate their latest equipment and offer us that new rig.

Yaesu presented its new FTM-10R transceiver, shown in Photo 1 mounted on the handlebars of a motorcycle. Yaesu says this rig's detachable front panel is waterproof and dustproof, ideal for installations exposed to the weather. The rig has an optional Bluetooth® wireless headset for hands-free operation. The radio supports FM broadcast receive in stereo along with an input for an external CD player or MP3 player. Clearly, Yaesu has put features into this rig with the aim of being the entertainment center for your ride.

Photo 1. The Yaesu FTM-10R remote head mounted on a motorcycle.

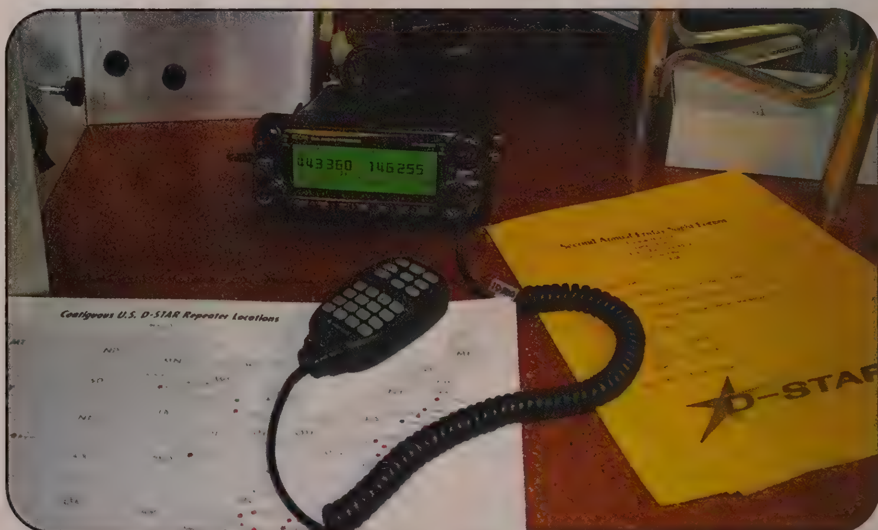

Photo 2. The ICOM IC-2820H dual-band FM transceiver with optional D-STAR capability.

At the ICOM booth, we found the IC-2820H, the latest dual-band transceiver with optional D-STAR and GPS capability (Photo 2). The rig includes a *diversity receive* mode that is intended to improve reception while mobile in the face of varying signal strength. Diversity reception uses two separate antennas spaced a small distance apart, each grabbing the signal at a different physical location, increasing the odds that one of them will hear the signal well. Although this approach is well known in the communications world, it is the first time I've seen it used in a VHF amateur radio. It will be interesting to see how much better diversity receive works in typical mobile situations.

Most dual-band FM rigs have a lower power output on the 70-cm band (compared to the 2-meter band), but the IC-2820H has a full 50 watts output power *on both bands*. The UT-123 option adds D-STAR capability and a GPS receiver to the IC-2820H. This is not just a GPS interface; this is a full-GPS receiver built into the rig, including an external GPS antenna. The GPS positional data is

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Photo 3. The Kenwood TM-V71A dual-band FM transceiver.

Photo 4. The Kenwood TM-V710, kept under glass at Dayton.

shown on the large transceiver display, and the transceiver can be configured to transmit position information at preset intervals. This is basically a D-STAR version of APRS, but not compatible for traditional AX.25 packet-based APRS.

Kenwood introduced the TM-V71A dual-band transceiver, also with a full 50 watts of transmit power on both bands (Photo 3). This rig includes features aimed at making Echolink operation more convenient. For the Echolink user, ten DTMF memories are there to store your favorite Echolink nodes. Just as important, Kenwood made it easy to set up this rig as an Echolink node, with the right computer interfaces built into the rig (optional PG-5H interface cable required).

Like many dual-band FM rigs, this radio has a cross-band repeat feature that retransmits the signal from one band to the other. Kenwood added an important improvement to cross-band repeat—an automatic identifier (CW or optional voice recording). Automatic identification is a key feature that has been missing for years. Unfortunately, TM-V71A IDer transmits every 10 minutes, even if the cross-band repeater has been idle. This makes it act more like a "beacon" than a well-behaved repeater identifier. (Usually, a repeater identifier remains silent until there is activity on the repeater.)

Kenwood also displayed the new TM-D710, the replacement for the popular APRS/packet rig, the TM-D700A (Photo 4). However, we are going to have to wait a while longer until this rig is available. There were no data sheets available at Dayton, and the rig is expected to go on sale this fall.

D-STAR Happenings

For the FM VHF crowd, the biggest buzz at Dayton centered on D-STAR. Of course, you would expect ICOM to be displaying their D-STAR line of equipment (Photo 5), but the topic of D-STAR showed up in several other places at the convention as well.

The D-STAR Forum was very well attended, even though it was held on Sunday morning—not exactly prime time for convention attendees! Greg Sarratt, W4OZK, ARRL Alabama Section Manager, and Jim McClelland, N5MIJ, of the Texas Interconnect Team, talked about how the deployment of D-STAR equipment was going in their respective locations (Photo 6).

Photo 5. The display of ICOM D-STAR radios at the D-STAR booth.

Previously, I had bumped into the work that the Texas team is doing, but I was not aware of how the Alabama section has embraced D-STAR with an emphasis on emergency communications. The Alabama section website indicates there are 14 D-STAR systems on the air in the state, with many of these repeater sites having repeaters on more than one band.

You may recall that I wrote an article on D-STAR technology for the Winter 2006 issue of *CQ VHF* ("D-STAR Digital Voice for VHF/UHF"). I received a few e-mail messages that basically said, "I don't see any reason for this new digital stuff; my analog FM rig is just fine." This is not a big surprise, as there are people out there who think single sideband is just too radical a technology to be used on the ham bands. The attitude I found at the D-STAR forum was just the opposite: Hams hungered for information on how this new-fangled mode works and how they can get involved with it. It reminds me of when AX.25 packet arrived on the scene years ago, with people interested in playing with the technology and figuring out how to use it.

Photo 6. *Jim McClelland, N5MIJ (left), and Greg Sarratt, W4OZK (right), discuss D-STAR repeater deployment at the D-STAR Forum.*

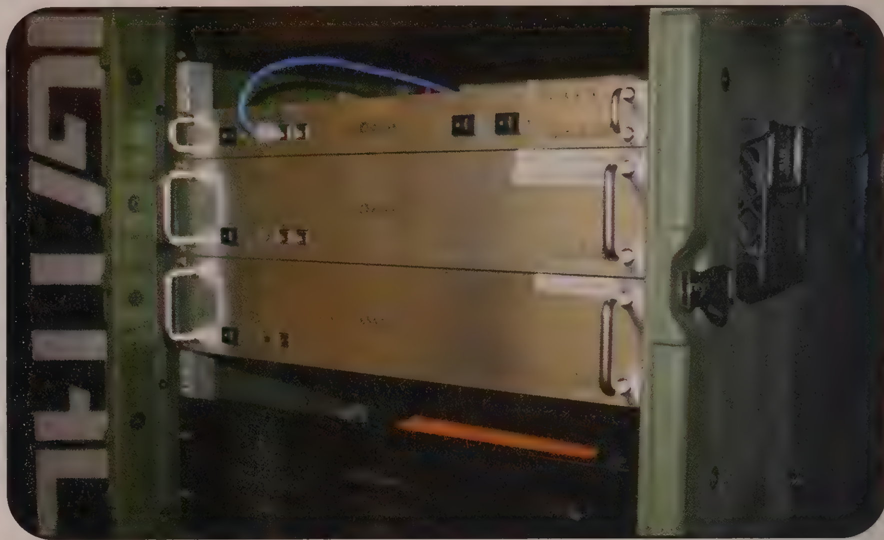

Photo 7. An operational D-STAR repeater on display.

Whether you think D-STAR is the future or not, it is refreshing to see the ham radio community excited about something new. After all, many of us have a strong interest in experimenting with radios and new technology.

At the Frequency Coordinators Forum, D-STAR was a hot topic. It seems that most of the frequency-coordination organizations are receiving requests for the coordination of D-STAR repeaters (Photo 7). This led to a lively discussion of "where to put them," since in many regions the available 2-meter repeater pairs are all coordinated. In some areas of the country, D-STAR repeaters are being dropped into the existing band plan, having either 20-kHz or 15-kHz channel spacing. This approach certainly works, but it does not take advantage of the narrower bandwidth of the D-STAR signals (more like 10-kHz channel spacing).

Robert Shepard, KA9FLX, Technical Committee Chair for the Illinois Repeater Association, put together a proposal for migrating existing analog FM channels to digital ones. Basically, the Illinois proposal provides for 10-kHz channel spacing on 2 meters, while 70-cm repeaters split existing 25-kHz channels to create 12.5-kHz digital channels. While the frequency coordinators tended to agree that there was a serious band-plan issue to be solved, there was no clear agreement on the best method for moving ahead.

Mark Thompson, WB9QZB, invited everyone to participate in the Yahoo group (illinoisdigitalham) that he started to discuss digital ham radio. Despite the "Illinois" name, this lively group has participants from all over the U.S.

Homebrew D-STAR

One of the issues with D-STAR is that ICOM is the only manufacturer selling equipment in the U.S. (Kenwood has marketed D-STAR gear in Japan but has not chosen to bring these products to North America.) Whether the perception is reality or not, outside of Japan D-STAR *looks like* an ICOM proprietary technology: If you are going to have D-STAR, you are going to have to buy ICOM.

Well, Robin Cutshaw, AA4RC, decided to change all that. Robin constructed and demonstrated a *homebrew* D-STAR 2-meter transceiver at his booth at the Hamvention®. Although the D-STAR standard is touted as "open," it still requires significant reverse engineering to make this radio work. Robin says he is committed to making his work available to everyone, so keep an eye on this website: <http://www.opendstar.org/>.

While it is still not clear where this will lead, it does prove that there is enough information, technology, and parts available out there for hams to construct D-STAR-compatible transceivers.

Is a D-STAR System a Repeater?

Another controversy winding its way through the aisles was this question of whether D-STAR systems are really repeaters. This apparently was initiated when a ham e-mailed Bill Cross, W3TN, of the FCC Wireless Telecommunications Bureau asking for clarification on whether D-STAR systems are repeaters or some kind of digital station. The argument goes like this: Since a D-STAR repeater takes in received digital data, processes it, and forwards it on to the transmitter, it operates as a store-and-forward digital station. Said another way, the repeater output is not really simultaneous with the repeater input; it is processed and delayed. Why is this important? Well, if a D-STAR system is not a repeater, then it doesn't need to be coordinated like a repeater, and it can be deployed on frequencies that are not specified for repeater operation.

Bill Cross spoke at the FCC Forum and was asked about this specific issue. He gave a very long answer (available for download as an audio file, see below), which I'll summarize this way:

- The amateur radio licensee is solely responsible for operating his station consistent with FCC rules and regulations.
- Don't believe everything you read on the internet, especially an e-mail that answers a question without including the context of the original question.

Okay, both of those statements are true, but they don't really answer the question of whether D-STAR systems are considered repeaters under the FCC rules. My opinion that it is an interesting armchair lawyer debate, but like most such debates it doesn't really accomplish much. I see D-STAR systems as being fixed in frequency, occupying a pair of duplex frequencies, and requiring frequency coordination to prevent interference. It sure

sounds like a repeater to me. (If it looks like a duck, quacks like a duck . . . it probably is a duck.)

Where's Project 25?

As I said earlier, the buzz at Dayton was around D-STAR, but occasionally we heard some comments about APCO Project 25. There are hams with P25 systems on the air, but there is no manufacturer pushing ham radio adoption of P25. It seems that the typical scenario is for hams who are involved in land-mobile communications to redeploy their favorite P25 repeater equipment onto the ham bands. Commercial P25 radios generally are more expensive than equivalent D-STAR gear, but the cost will come down as the commercial gear becomes available on the used market. Commercial radios usually are very channel oriented and don't have the flexible features of your typical ham rig. This will limit the adoption of P25 by the ham radio community, unless, of course, some innovative amateur radio manufacturer decides to offer a P25 rig tuned specifically for the ham market. Now *that* could get interesting.

Classic FM Gear

A visit to Dayton is not complete without a trip or two through the flea market. The flea market is usually a great spot to pick up well-used land-mobile FM gear from GE, Motorola, etc. I spotted a pile of handheld rigs starting at the bargain price of $5 each (Photo 8). There is always an extensive collection of repeater parts and repeater systems, everything from used duplexers to complete repeater systems (Photo 9). There is always so much stuff from which to choose that I have to be careful not to take home that "treasure" that ends up being on my table at the next local swapmeet.

Summary

Attending the Dayton Hamvention® was a great experience, one that I highly recommend. Thanks to the members of the Dayton Amateur Radio Association (DARA) for putting on an outstanding ham radio event.

If you have thoughts about this column or FM VHF in general, please drop me a note at <bob@k0nr.com> or stop by my blog at <http://www.k0nr.com/blog>.

73, Bob, KØNR

Photo 8. Who says ham radio has to be expensive?

Photo 9. A UHF repeater for sale in the flea market.

Resources

Open D-STAR: <http://www.opendstar.org/>
Texas Interconnect Team: <www.k5tit.org>
Alabama Section D-STAR: <http://www.arrl-al.org/Alabama_link.htm>
KA9FLX Digital Migration Plan (Illinois Repeater Association): <http://www.ilra.net/The%20Digital%20Migration-IRA_R0428071.pdf>
Illinois Digital Ham group: <http://groups.yahoo.com/group/illinoisdigitalham/>
The Rain Report (June 21, 2007), audio recording of comments by Bill Cross, W3TN, concerning D-STAR repeaters: <http://www.therainreport.com/rainreport_archive/rainreport-6-21-2007.mp3>

By Tomas Hood,* NW7US

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Calling All North American VHF Amateur Radio Operators!

What is the most exotic propagation mode you personally have experienced while operating on VHF? Pinging your signal off of a meteor trail? Catching aurora-mode DX? Making contacts by way of back-scatter propagation? Or have you worked stations in nearby states by way of sporadic-*E* propagation?

While there are a fair number of VHF operators manning the weak-signal and non-FM-mode segments of the VHF ham bands, there seems to be a significant lack of serious, systematic observations on a grand scale in North America. There are those involved with PropNET <http:// propnet.org/>, and there are many who post individual spots on DX clusters. However, is there a concerted effort by the VHF community in North America to collect and study the vast operational data in a way that uncovers the rich VHF radio signal propagation phenomena that occur each season?

Such a systematic activity is alive and well in Europe. For instance, you can find a great amount of material presented at the "Amateur Radio Propagation Studies" website (http://www.df5ai.net/) by Volker Grassmann, DF5AI. He postulates, and I concur, that the absence of systematic studies of operational data is an obstacle in the discovery and deeper understanding of VHF radio propagation in North America. The majority of the studies Volker presents on his website are Eurocentric.

There are unanswered questions about VHF propagation in North America. For instance, Volker points to the different propagation characteristics of Europe and North America during the sporadic-*E* season between May and September. Does sporadic-*E* activity in North America track with the level of activity in Europe, or are there vastly different systems at work in the sporadic-*E* season in each area of the world?

Because there does not seem to exist any systematic collection of daily and seasonal VHF DX information on a grand scale (more than a handful of die-hard VHF stations posting on DX reflectors), it is difficult to analyze the real VHF propagation phenomena across the vast geographical area of North America. Scientific background data such as ionosonde, sferics, and upper-air sounding data is easily obtained. However, there's very little information from the VHF community about daily continent-wide propagation on a grand scale (hundreds of operators representing all of the geographical regions).

What is FAI?

An example of what needs to be studied by the VHF community is the Field-Aligned Irregularities (FAI) related propagation modes. A field-aligned irregularity is a dense "cloud," or bubble, that becomes aligned with the powerful geomagnetic field lines that run from each of the Earth's poles. A great deal of scientific research has been and is being performed to understand the FAI phenomenon. However, the ham radio VHF community knows only the most obvious occurrence of FAI propagation, such as when the dense ionized patches form during aurora and cause VHF signals to refract in the *E* region of the ionosphere, where the dense patches ride the turbulent geomagnetic field lines, causing broad Doppler shifts in frequency.

However, there is a lot more FAI activity occurring all the time, according to the research coming out of many universities and scientific communities. A study by scientists in India revealed that a total eclipse of the sun causes cooling within the dark, supersonic disc created by the moon's shadow as it races across the Earth. In turn, that cooling causes gravity waves that form plasma disturbances. These plasma waves align with the magnetic field lines and can refract radio waves at some range of frequencies.

It follows, then, that other forms of plasma disturbance in the ionosphere can cause the same formation of dense patches of ionized gas, which in turn can become field-aligned and could then possibly refract radio signals. Could perhaps lightning jets, or temperature inversions, or other gravity-wave events cause FAI? Non-amateur-radio researchers say yes. Their research even hints at possible meteor-trail plasma clouds contributing to FAI propagation. Have we as a community uncovered any of these occurrences? Do we know what to look for?

We need a very large increase in the number of radio operators attempting long-distance communications on the low VHF spectrum, using many different modes and techniques. Also, with that increase in the number of researchers, we need to have a centralized place to collect all of the data, and then a way to begin analyzing the patterns and events to see what really is possible on VHF. I am convinced that we have only begun to scratch the surface of understanding VHF propagation.

That's just on VHF. What about UHF research on a grand scale? Remember, "you can't work 'em if you can't hear 'em," and you can't hear them if you are not working the band. Not enough research is being done on a continent-wide basis, and a large number of operators is needed on a daily basis to really uncover any unique—rare or not—phenomena that might exist on VHF and UHF by way of the ionosphere.

If you are new to the world of VHF radio, I challenge you to explore how you might be a part of the movement to research the "wild frontier" of North American VHF propagation on a large scale. This is a call for operators, data handlers, researchers

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and analyzers, and promoters of VHF propagation exploration. If you are a veteran VHF DXer, contribute your knowledge and passion to this new initiative. Can you write software to help analyze such vast data? Perhaps you are great at organizing data on such a scale. Most of all, if you have any interest in the science behind getting your signal from here to there, any interest in VHF operation beyond chatting on a local repeater, then join up with as many other VHF explorers on the air and let's see what we can discover.

The *Perseids*

We are entering a period of the year in which we can work VHF DX off meteor trails. One of the most reliable yearly meteor showers is the *Perseids*. The *Perseids,* like other meteor showers, is named after the constellation from which it first appeared to have come. This shower's constellation is Perseus, which is located near Cassiopeia. The *Perseids* favor northern latitudes. Because of the way Comet Swift-Tuttle's orbit is tilted, its dust falls on Earth's Northern Hemisphere. Meteors stream out of the constellation Perseus, which is barely visible south of the equator.

Lewis Swift and Horace Tuttle, Americans working independently, discovered a comet in August of 1862. Three years later, Giovanni Schiaparelli (of Martian "canali" fame) realized it was the source of the August *Perseids* meteors. The comet, now known as Comet Swift-Tuttle, leaves a trail of dust that Earth passes through during August.

This year, the *Perseids* will be active from July 17 through August 24, and should peak between 0500 UTC and 0730 UTC, August 13. The number of visual meteors is expected to be about 100 per hour. It is possible, using high-speed CW, to realize a much higher hourly rate, since many meteors that are not visible might contribute to the ionization necessary for long-distance contact.

The *Perseids* shower begins slowly in mid-July, featuring dust-size meteoroids hitting the atmosphere. As we get closer to August 12, the rate builds. For working VHF/UHF meteor scatter, this could prove to be an exciting event.

The best time for working the *Perseids* VHF/UHF via meteor scatter in North America is during the hours before midnight, until about 5:00 AM local time.

The characteristic *Perseids* burn is bright white or yellow and typically lasts less than half a second. The brighter meteors usually leave a persistent train, or "smoke trail," that lasts a second or two after the meteors have vanished. This is not really smoke at all, but rather ionized gas created by the meteors passing through the atmosphere at tremendous velocities. It is this trail that potentially reflects the VHF radio signal.

Other Meteor Showers of the Summer

There is very little anticipation of significant *Draconids* activity this year. The *Draconids* is primarily a periodic shower which produced spectacular, brief meteor storms twice during the last century, in 1933 and 1946. Most recently, in 1998, we saw a moderate peak of the Zenith Hourly Rate (ZHR) reaching 700. This was due to the stream's parent comet, 21P/Giacobini-Zinner, returning to perihelion. There was a small outburst of activity in 2006. There is discussion that this year the activity could be a strong minor storm.

The *Draconids* meteors are exceptionally slow-moving, a characteristic that helps separate genuine shower meteors from sporadics accidentally lining up with the radiant. This is a good shower to work meteor-scatter mode, since we might see storm-level activity this year.

Meteor activity improves somewhat with the *Orionids* later in October. The *Orionids* shower is active from October 2 through November 7, peaking on October 21. This year the hourly rate could reach about 30 meteors per hour. This is expected to increase in the next year, as well.

For more information, take a look at <http://www.imo.net/calendar/2007>. Check out <http://www.meteorscatter.net/metshw.htm> for a very useful resource covering meteor scatter and up-coming showers.

The Solar Cycle Pulse

The observed sunspot numbers for April and May 2007 are 3.7 and 11.7. The smoothed sunspot counts for October and November 2006 are 14.2 and 12.7.

The monthly 10.7-cm (preliminary) numbers for April and May 2007 are 72.4 and 74.5. The smoothed 10.7-cm radio flux for October and November 2006 is 79.4 and 78.5, respectively.

The smoothed planetary *A*-index (*Ap*) for October and November 2006 is 8.6 and 8.5. The monthly readings for April and May 2007 are 9 and 8.

The monthly smoothed sunspot numbers forecast for August through October 2007 are 13.5, 15.5, and 18.1, while the monthly smoothed 10.7-cm radio flux is predicted to be 75.5, 76.4, and 77.8 for the same period. Give or take about 12 points for all predictions. (Note that these are preliminary figures. Solar scientists make minor adjustments by careful review after publishing.)

What do these numbers indicate? It looks very possible that this is the start of solar Cycle 24. While many expert forecasters predicted a delayed ending and prolonged start to a new cycle, the current numbers indicate that the sun may be ramping back up. Could Cycle 24 be the big cycle that some have predicted? More recent predictions by some, notably at NASA, forecast a moderate-to-weak solar cycle. However, those same forecasters predict that perhaps Cycle 24 won't start until late 2008. I'm predicting that the earlier forecast, which indicates that Cycle 24 will be one of the strongest since the 1950s, is more accurate, and that the end of Cycle 23 has just occurred.

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter, etc.). I'll create summaries and share them with the readership. You also are welcome to share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information can be found at my propagation center at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

CQ's 6 Meter and Satellite WAZ Awards

(As of July 1, 2007)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
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18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
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38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
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40	ES2RJ	1,2,3,10,12,13,19,23,32,39
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45	G3VOF	1,3,12,18,19,23,28,29,31,32
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79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Light Speed

Tuning the bands in search of an interstellar CQ, we become aware that the universe is immense. When contemplating its magnitude, we need a whole new yardstick. For astronomers, that yardstick is the light year (LY), the distance light travels in one year.

However, that doesn't tell us very much, does it? I mean, how many of us can close our eyes and visualize the speed of light? I can't. I can board an airliner and know that I am traveling at, say, 78 percent the speed of sound, but even that velocity challenges my comprehension.

Just how fast does light travel, how far does it go in a year, and how can we use that knowledge to assess our place in the universe? I could tell you that a light year is a quarter of the distance to the nearest star. However, from my vantage point under this ocean of air, one star looks pretty much as remote as the next, so that doesn't clarify things at all.

Still, Mach 1, the speed of sound, is a familiar concept to most of us. We know that if we see a lightning flash and then 5 seconds later we hear the thunder roar, the storm must be about a mile away. We know this because sound travels at about one fifth of a mile per second, and light (at least over such limited distances) seems to arrive instantaneously.

Well, in fact, light travels about a million times faster than sound, so we can quantify the speed of light, very approximately, as Mach 1 million. Thus, a light year is about how far we'd go in a million years, traveling at Mach 1, or how far the Concorde (which flew at Mach 2) would have gone in 500,000 years—if it didn't have to stop for gas.

Of course, we all have to stop for gas, sooner or later. My little Volkswagen Beetle gets about 30 miles to the gallon on a good day. Just how many gallons of fuel would I need to drive a light year, and how many times would I have to stop to fill up?

*Executive Director, The SETI League, Inc., <www.setileague.org>
e-mail: <n6tx@setileague.org>

Dr. SETI's spacecraft orbits the sun at about one 10-thousandth the speed of light. Its fuel economy is 200-billion gallons per light year (see text).

The textbooks tell us that one LY is about 6-trillion miles. Let's see if we can sink our teeth into that one. Well, 6 trillion is 6,000 billion, so at 30 miles per gallon, we merely need to divide 6,000 by 30 (that equals 200) and then tack a billion on the end.

Okay, 200-billion gallons of fuel. A 20-gallon gas tank means we need to fill up (let's see, 200 billion divided by 20 equals…) 10-billion times. How long do you suppose that will take us?

Each gas stop consists of pumping the petrol, paying for it, visiting the rest-room, grabbing a cup of coffee, and maybe making a phone call to home to keep the spouse apprised of our progress. Let's say 12 minutes per pit stop. That's 5 to the hour, which means we spend—let's see now, 10 billion divided by 5 equals—2-billion hours spent at interstellar service plazas. I wonder what that is in years?

Now there are 24 hours in a day and 365 days in a year. Multiplying the two together, we see that a year consists of just under 10-thousand hours. (I told you this would be approximate.) Dividing 2 billion by 10,000, we find we're spending 20,000 years just fueling up. That's for a hypothetical one light-year trip, and we haven't even begun to calculate the driving time!

Were this space ship on which we reside traveling at the speed of light, it would, of course, travel one LY in exactly one Earth year. In fact, however, Earth is a slow boat to nowhere. Is it possible that during its brief history our planet has traveled light years?

Actually, it has, if you count its curved path around our sun. Let's calculate the Earth's annual orbit in light years:

We start with the known fact that it takes 8 minutes for sunlight to reach us. (We know this because when we flip the switch to turn off the sun, it takes 8 minutes for the sky to go dark.) Well, that places the Earth 8 minutes from

its source of power, so we'll use 8 light minutes for our orbital radius.

One trip around the sun takes us just a year. Not counting the sun's own motion around the galactic center, the distance we travel in a year is (pi times diameter equals … two pi times radius, equals …) 50 light minutes. Rounding up, we'll call it a light hour.

Since Earth travels about a light hour per year, and a year is almost 10,000 hours long (remember?), we can wee that we're orbiting the sun at one 10-thousandth the speed of light, or Mach 100. Did you realize that you live on a supersonic spacecraft? Furthermore, we see that in about the last 10,000 years our planet has traveled about one light year.

Ten thousand years … let's see. That's about how long it's taken us humans to advance from primitive hunter-gatherers to … primitive hunter-DXers.

What does all of this have to do with interstellar communications and the search for radio signals in space? Actually, more than a bit. Let's imagine our planet as a starship. We somehow manage to snap the gravitational rubber-band that binds us to our sun, and we shoot off in a straight line, toward the stars. Here we go, at one 10-thousandth the speed of light. It takes us 10,000 years to travel one LY. If we're lucky enough to be shooting off in the right direction, it takes us about 40,000 years to reach the next nearest star. And if we visit about a thousand stars, we're likely to find one being circled by a habitable planet. This means that shopping for a new home could take us 40-million years, give or take.

Is it any wonder that some of us choose to embrace electromagnetic communications, rather than merely going there?

73, Paul, N6TX

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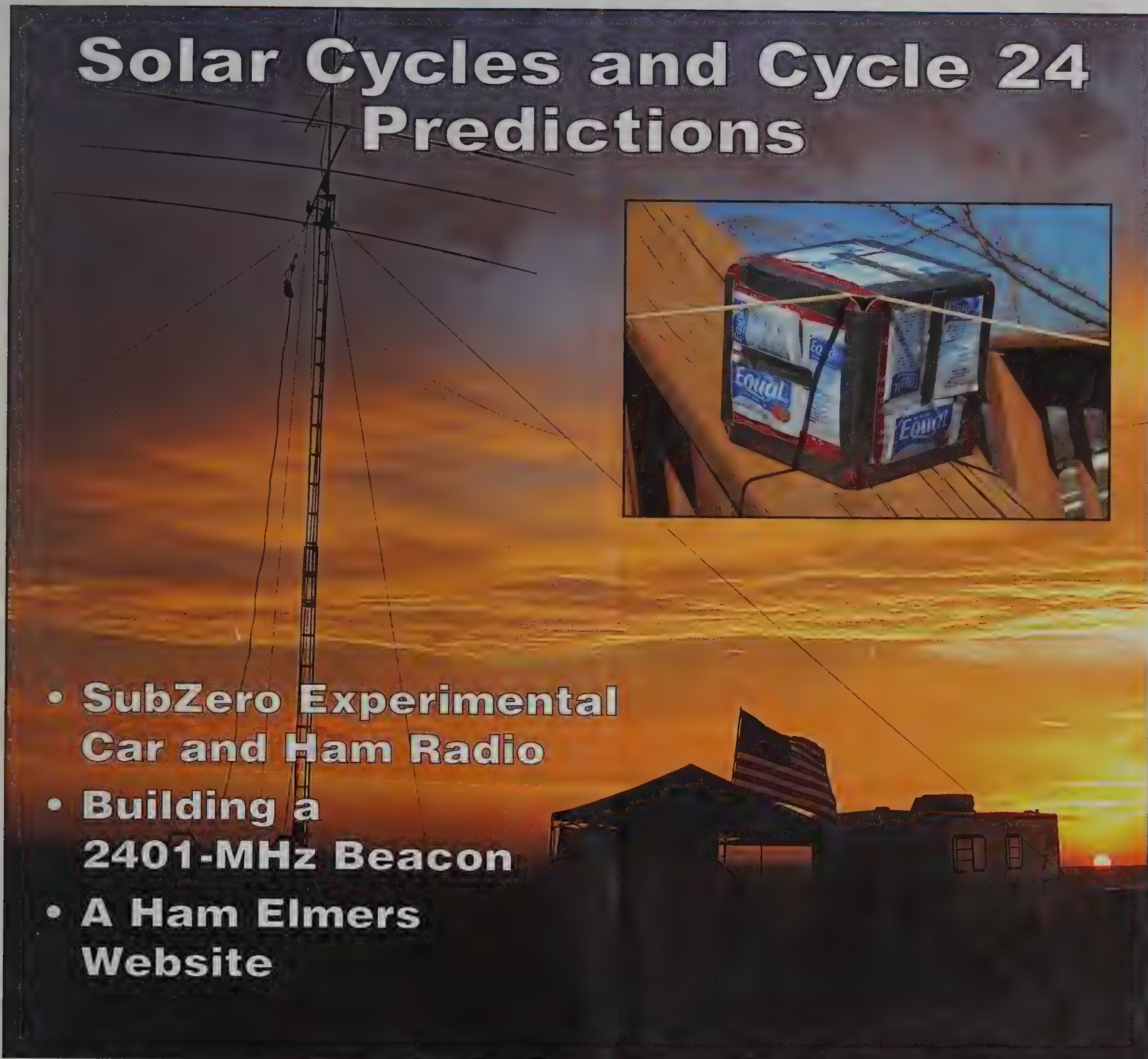

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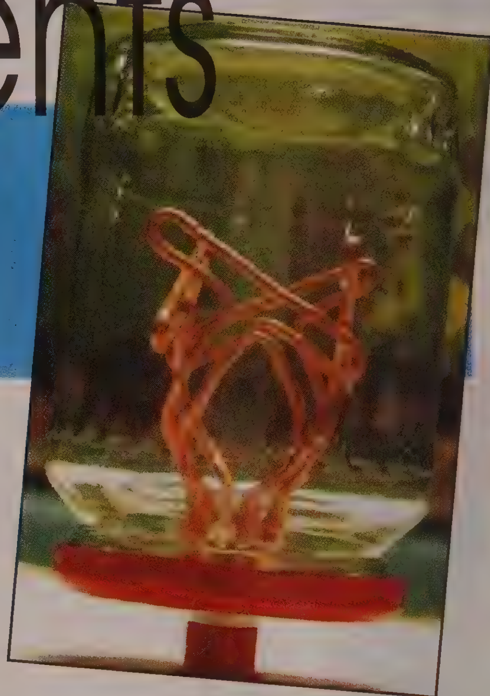

Fall 2007
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FEATURES

COLUMNS

DEPARTMENTS

On The Cover: Sunset on Mount Sunflower, Kansas, at the site of the K4S effort in the 2007 14er event. For more information on the K4S operation and the one from atop Pikes Peak, Colorado, see the "FM" column on page 58. *(Photo by Bruce Frahm, KØBJ)* Inset: CoasterSat I, a new AMSAT lab's first "satellite." For details see Paul Shuch, N6TX's "Orbital Classroom" column on page 79. *(Photo courtesy of N6TX)*

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Doing a Better Job of Telling Our Stories

This past August 16–17, my wife Carol, W6CL, and I were among the nearly one hundred participants at the 2007 Global Amateur Radio Emergency Communications Conference (GAREC-07), which was held in Huntsville, Alabama during the run up to the Huntsville Hamfest. This was the third such conference, and the first one to be held in the U.S. (the other two were held in Europe). Among the participants were representatives from the IARU, the ARRL, Army MARS, American Red Cross, Southern Baptist Disaster Relief, Department of Homeland Security, The Salvation Army, a Coast Guard auxiliary, as well as many appointees from the ARRL field organization. International participants came from Ireland, France, Bulgaria, Finland, The Netherlands, South Africa, Brazil, Canada, and Trinidad and Tobago. I was fascinated by the various stories told of amateur radio involvement in emergency communications.

This past September 28–29, I attended the Western Region NASA Space Grant Consortium conference, which was held in Oklahoma City, Oklahoma. Participants included directors of most of the state NASA space-grant consortia west of the Mississippi River, along with Louisiana. Also participating were affiliates of these various space-grant consortia, as well as NASA officials and faculty fellows affiliated with NASA.

I again was fascinated by stories told by the various participants of student involvement and student-driven projects taking place throughout the country. One such story was told by Mike Voglewede, a teacher at Northwood Public School, in Northwood, North Dakota. Northwood was in the news recently because of the August 26, 2007 devastating category four tornado that nearly destroyed the town. In the aftermath of the tornado, Mike spoke of the past and the future for his school. The immediate future for the school is it was so totally destroyed that it will have to be completely torn down and a new school built in its place.

What was not destroyed, however, is the spirit of several of the students who have participated in Northwood's after-school program. Here is their story, thanks to the efforts of Mike, his wife, and others in the school and the community.

It was about a half dozen years ago when Mike had the idea to bring robotics to the classroom—after school. Robotics is the study and building of robots for various tasks. What is important about learning robotics is that robots increasingly are being used throughout industry to perform a variety of small and large tasks.

Robotics as a subject is one that both excites and educates youth. It excites youth because it is hands on. Young people build projects to accomplish tasks and in the process learn a number of skills, including creative thinking and working together in teams—in other words, learning how to cooperate with others in order to accomplish a task, something about which we adults sometimes need refresher lessons.

While robotics is an excellent teaching device, it is a non-traditional subject for many public K-12 schools that are constrained by the "no child left behind" mandate, with which most of today's public schools now must comply. Such was the case with Northwood Public School. Undaunted by this constraint, Mike and his friends decided to develop an after-school program centered on robotics. In time, the program almost took on a life of its own. The after-school program lasted from 3:30 in the afternoon to 9:30 at night. The parents got on board and began a rotational meal-serving program. The PTA went from a few in attendance to hundreds, and not all of them parents. Local industry got involved in the school, with businessmen and tradesmen becoming mentors for the students. At its peak, there were more Northwood students involved in the robotics after-school program than were on the football team.

Their hard work has paid off. Teaming with nearby Hatton Public School and entering multiple competitions, the robotics team has won many awards over the past several years.

While the tornado set back the program a bit, it has not stopped it nor kept outside sources from supporting it. For example, as demonstration of the faith it has in the robotics program, the North Dakota Space Grant Consortium awarded it a special $5,000 grant to rebuild the robotics library.

While the robotics story is not directly related to amateur radio, one can easily see that amateur radio could become a part of it, or a similar program that incorporates amateur radio could be started in another school. Perhaps Mike's story might inspire you to start one in your local school.

What I found to be in common between these two conferences was that while participants in both conferences were very good at telling each other their stories, they seemed to be unable to tell their stories to others outside of their peers. For example, apart from my mention of the GAREC-07 conference in my column in the November 2007 issue of *CQ* magazine and the article posted online at the ARRL's website (http://www.arrl.org/news/stories/2007/08/24/102/), very little publicity has been given to the many stories that have emerged from that conference. Furthermore, apart from its mention here, to date none of the other amateur radio media has covered the Western Region NASA Space Grant Consortium conference.

The tragedy of this lack of publicity is that both venues are sources of great stories concerning amateur radio or potential amateur radio involvement. Regarding GAREC-07, in the aftermath of 9/11 and Hurricane Katrina, one of the two emerging stories in amateur radio is the huge resources that its operators can commit to emergency communications—resources that heretofore have not been matched by the professionals at any level.

The other emerging story in amateur radio is education. Regarding amateur radio and education, the NASA Space Grant Consortium program is a very large source for such stories. You have already read stories of amateur radio involvement in the consortium in previous issues of *CQ VHF* magazine. One example is Professor Kevin Carr, KE7KVT's story "Through the Back Door: A Teacher's Journey into Amateur Radio," which appeared in the Spring 2007 issue. Kevin's employer, George Fox University, is an affiliate of the Oregon Space Grant Consortium. Ironically, when I showed Kevin's article to Jack Higginbotham, OSGC's director, he was totally unaware of the national publicity that GFU had received via this magazine.

My point in this editorial is that we need to do a better job of telling our amateur-radio-related stories. No one else is going to do it for us—except perhaps your doggedly persistent editor. Yet even with my single-handed efforts, I still cannot discover or uncover all of your stories. In order to do so, I need your input—either by way of an article in *CQ VHF* magazine or a few paragraphs in my column in *CQ* magazine.

Therefore, if you have a story to tell, then please write it and get it to me. If you have a story lead, then send it to me and I will track it down. Please contact me via my e-mail address (n6cl@sbcglobal.net) with your story or story idea. I look forward to hearing from you in the very near future.

Until the next issue…

73 de Joe, N6CL

SubZero
Alternative-Energy-Powered Vehicles and Amateur Radio

SubZero IV, a hydrogen-cell-powered car, is the fourth in a series of experimental cars built by students of UND's SEA. A requirement of membership in SEA is that one must possess a Techinician class license to drive the car. Here is the story.

By Tim Langemo, KCØWSZ, and Brandon Burnette, KCØYXE
University of North Dakota
Society for Energy Alternatives*

SubZero IV H_2 travels down the road with a chase vehicle close behind.

Rising gas prices have been in the headlines for the past several years, and better gas mileage seems to be on almost everyone's mind. What can be done to reduce our dependence on foreign oil? While many theories on this subject exist, we have come across one in particular with which we agree—hydrogen.

The Society for Energy Alternatives (SEA) is a student organization at the University of North Dakota that includes students from every college on campus. Founded in 1996, our group has sought to utilize various alternative fuel sources, such as solar power and now hydrogen, in transportation applications. After building three solar cars (SubZero, SubZero 2, and SubZero 3) between 1996 and 2001, SEA began looking for a new, more viable fuel source for use in a transportation setting.

The sun does not always shine thanks to the rotation of the Earth, making solar-powered vehicles impractical. Clouds and rain can also affect the performance of solar cells. Add in the infant-like fragility, and it becomes fairly clear that a different direction is needed. Compressed hydrogen gas offers a solution to this problem. Hydrogen is very clean and contains a higher density of energy than gasoline or even ethanol at a given volume. When properly stored, it is no more dangerous than the gasoline or diesel fuel that powers almost every vehicle on the road today.

Our group settled on the use of a hydrogen proton exchange membrane (PEM) fuel cell for our fourth alternatively fueled vehicle, SubZero IV H_2. The car, designed between 2002 and 2004 and built during the 2005 academic year, was the first fuel-cell powered vehicle to be built from the ground up by university students in the United States.

Powered by a 10-kilowatt Hydrogenics fuel cell, the drive train includes a bank of ultracapacitors and a 7-hp DC brushless motor. The single-wheel drive manages to propel SubZero IV H_2 to a blistering top speed of 45 mph. The ultracapacitors provide an electrical buffer for the fuel cell when the electric motor is engaged, as well as a source of emergency power so that the car may be pulled safely off the road should it become necessary to shut down the fuel cell while operating the car.

During July 2005, the team participated in the North American Solar Challenge. The race covered 2,500 miles of public highways between Austin, Texas and Calgary, Alberta, Canada. Seventeen solar-powered vehicles participated in two classes, along with one hydrogen fuel-cell car operating in a demonstration class. While our car did not finish the competition in first place overall, we managed to win our class in our first attempt with the fuel-cell car. Some will point out that we also finished last in our class. Overall, the vehicle placed 14th, beating four solar cars over the 2,500-mile competition.

Along the way, we achieved an observed highway fuel economy of 125 miles per kilogram. Hydrogen is measured in kilograms, where one kilogram of hydrogen has the approximate energy equivalency of one gallon of gasoline. With about 2 kg of on-board storage capacity, we were able to go 250 miles per fill, not much different than the average auto-

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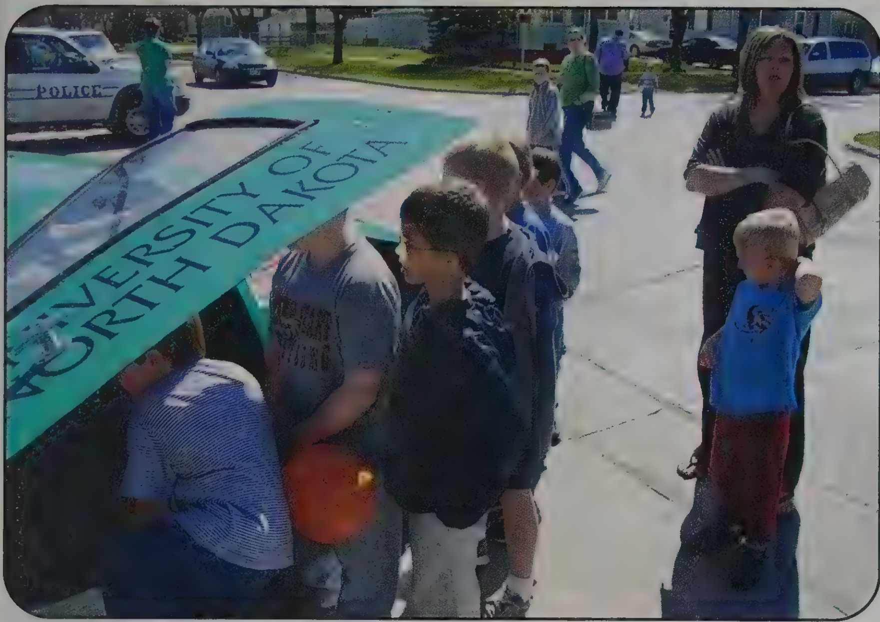
phone: 701-777-4110
e-mail: <sea@und.edu>
website: <www.und.edu/org/sea>



Local school children line up to sit in the driver's seat at an annual science day in Grand Forks, ND. The rig was turned off, so the repeated use of the push-to-talk button by the children did not produce any spurious transmissions.

mobile. If our team had access to a hydrogen compressor, we would be able to pressurize our tanks to their rated 5,000 psi and have an on-board storage capacity of about 4 kg, enough to travel about 500 miles.

When SubZero IV H_2 is being operated on public roads, the State of North Dakota requires that a "chase vehicle" follow it with flashing amber lights to warn other motorists of the presence of an experimental vehicle. In addition, our team uses a lead vehicle with flashing amber lights to lead the convoy around, and notify the driver of the fuel-cell vehicle about any changes in road conditions. All three vehicles keep in contact over the amateur radio bands. Over the years, our team has tried using FRS, GMRS, and CB for communications. We found that these systems just did not have the range and reliability that we demanded of them. We found that 2-meter simplex transmissions met our criteria quite well. Because we utilize the ham bands, in addition to needing a driver's license to operate SubZero IV H_2, a Technician class license is needed as well.

At the beginning of the fall 2007 semester, our team had over 80% of our members licensed to operate the Technician class bands. Our unlicensed team members who have joined the group this semester all are encouraged to obtain their Technician license. With a large pool of members, plenty of help is available to teach the principles that an operator needs to know to obtain a license. Also, with the recent elimination of the Morse code requirement, some of our members have expressed interest in upgrading to earn some HF privileges in addition to the frequencies available on the Technician bands.

Our team does not require the members to obtain their own rigs to operate on the bands. We have several mobile radios/antennas, as well as a couple of handhelds that our licensed members are welcome to check out at any time. This gives them a chance to learn to operate outside of the organization and make contacts with people they don't see at team meetings every week. Several members have gone on to purchase their own rigs, which in turn frees up other radios for other members to use.

Outside of the organization, many of our members have become more active with not only the local FORX radio club in Grand Forks, North Dakota, but clubs in their home towns when they are on summer break. Field Day 2006 was Tim's first exposure to the real world of amateur radio, only about a month after getting licensed as KCØWSZ. SubZero IV H_2 was hooked up to the SSB radio so the club could receive points for alternative-energy use. Watching Charlie, KIØLS, and Dick, KAØHDN, make five contacts in what seemed like the blink of an eye, he was "bitten by the bug." Field Day 2006 was cut short for Tim and a few others from the team when they needed to attend the wedding of two alumni from the team.

A few of our members got the chance to show SubZero IV H_2 at the Dayton Hamvention® in April this year. It was a great experience for us. We were able to share our experience with anyone who stopped to look at our car. The Hamvention® is the largest expo we have been to in terms of attendance. Because of that, we were exposed to a large variety of people from all over the country and the world. By nature, ham operators are innovative people. Our team requires innovation to be successful. People walked up to us and after getting the basic rundown

Brandon, KCØYXE (left), shares his experience with hydrogen fuel cells with North Dakota Congressman Earl Pomeroy (center).

Josh, KCØUBH (left), and Craig, KCØYXC (right), explain the operation of the car to tailgaters before a University of North Dakota football game.

on the project, started asking questions. Before the Hamvention®, we had never been asked a question about the project that we could not answer. Two questions were fielded to us that sent us home searching for answers. It felt great to ponder something about our car during the drive home.

Field Day 2007 was another great experience for some of our members. College students make good laborers for moving things such as generators, setting up the guy wires for the antennas, and hauling in the food after the grocery store run. After getting all set up, the real fun began. Tim, KCØWSZ, and Trent, KCØYXH, spent most of the day with Rod, KEØA, logging contacts at the CW station. Even though the FCC dropped the Morse code requirement for the General class license, we have members who have expressed an additional interest in learning code when they can get a break from their studies.

Late this summer, severe weather threatened the greater Grand Forks area. Tim, along with fellow team members Trent and Sarah, KCØUKW, went out to the National Weather Service and began to learn the procedures that are followed by the SKYWARN net control operator. When SKYWARN training rolls around in the spring, all of our members will be encouraged to attend.

This fall we are beginning work on our fifth car, SubZero V. This next vehicle will be a departure from some of our previous projects. However, this does not mean that we will be severing our connections to the ham radio community. Subzero V, like our previous vehicle, will use a power system to which we are not accustomed. It was decided that a hybrid drive system would be the power source for our next vehicle, incorporating and synchronizing two systems to create a drive train that is greater than the sum of its parts. We will use this vehicle to compete in the 2008 Society of Automotive Engineers (SAE) Formula Hybrid competition. The change of venue was brought on by several factors, but most of all we relish this opportunity to put our ham ingenuity to use towards the electrical system design.

Data acquisition has always been important to our program, as it is with any engineering endeavor. In the past, data has been extrapolated based upon vehicle performance and known input. For our newest vehicle we plan to use real-time electronic data acquisition over amateur radio frequencies. This will allow us to record vehicle metrics throughout the various events at the competition.

For those of you who are curious, or happened to ask us about it at the Hamvention®, APRS has not been utilized in any of our projects. This is an additional aspect of amateur radio that we are considering adding to our current project.

Upon graduation, our average member will have seven years left on his or her amateur radio license. We hope the skills learned operating amateur radio in our organization will carry through to our endeavors after we depart from the University of North Dakota.

Field Day 2006. Organization alumni Anna Vosgerau Severson, KCØNDB, and Keith Severson, KCØUIT, left the wedding chapel in the SubZero IV H_2.

Author Bios

Tim Langemo, KCØWSZ, from Minot, ND, earned his Technician license in May of 2006. He is a junior at UND and has been a member of SEA since the fall of 2005. Tim is the Project Manager for SubZero V. He will graduate in May 2009 with a B.B.A. degree in Information Systems.

Brandon Burnette, KCØYXE, from Minnetonka, MN, earned his Technician license in November 2006. He is a senior at UND and has been a member of SEA since the spring of 2005. Brandon is a past-president and acting vice president of the organization. He will graduate in December 2008 with a B.S. degree in Industrial Technology.

Solar Cycles and Cycle 24 Predictions

Based on a paper presented at the 41st Central States VHF Society Conference in San Antonio, Texas on July 28–29, 2007, KH6/K6MIO begins this article with the *F*-layer and the Sun. He then discusses and summarizes the various predictions of solar Cycle 24 that have been made to date. Significant portions of this article also appeared in the *Proceedings* of the above-mentioned conference.

By Jim Kennedy,* KH6/K6MIO
Gemini Observatory, Hilo, Hawaii

On 6 meters, F_2 propagation can produce dramatic results. The *F*-layer is ionized primarily by extreme ultraviolet (EUV) radiation from the Sun. The intensity of solar EUV is strongly dependent on the phase of the solar activity cycle. Unfortunately, the average level of solar EUV is not sufficient to raise the maximum usable frequency (MUF) above 50 MHz. Consequently, 6-meter *F*-layer propagation is confined almost entirely to the *peak* years of the solar activity cycle.[1]

Managing radio propagation, satellite health, and power-grid issues all lead to an interest in predicting future solar activity, on both short and long time scales. There are actually two intimately related "solar cycles": the *activity* or "sunspot" cycle and the solar *magnetic* cycle.

Solar Activity Cycle

The sunspot cycle peaks roughly every 11 years. Sunspots are always found in pairs or groups. The spots and groups occur in two latitude bands, one north and the other south of the solar equator (Figure 1). They come and go within those latitude bands with end-to-end lifetimes of a few days to several weeks.

As will be shown in this article, sunspots are the visible effects of loops of powerful magnetic fields arising from within the Sun that have then floated up and bulged out above the Sun's visible surface (Figure 2).

The east-west leading spot(s) in a pair (or group) have the opposite magnetic polarity from that of the trailing spot(s). If the leading spots in the Southern Hemisphere band have one polarity, then the leading spots in the Northern Hemisphere band have the opposite polarity—that is, the direction of the field between the leading and following spots in the south are opposite of those in the north (Figure 3).

As the Sun rotates on its axis every 27 days or so, sunspot pairs and groups appear to march across the Sun from east to west, being visible for up to 14 days as they travel from limb to limb and then rotate out of sight around the far side. If they live long enough, they return to the near side about 14 days later.

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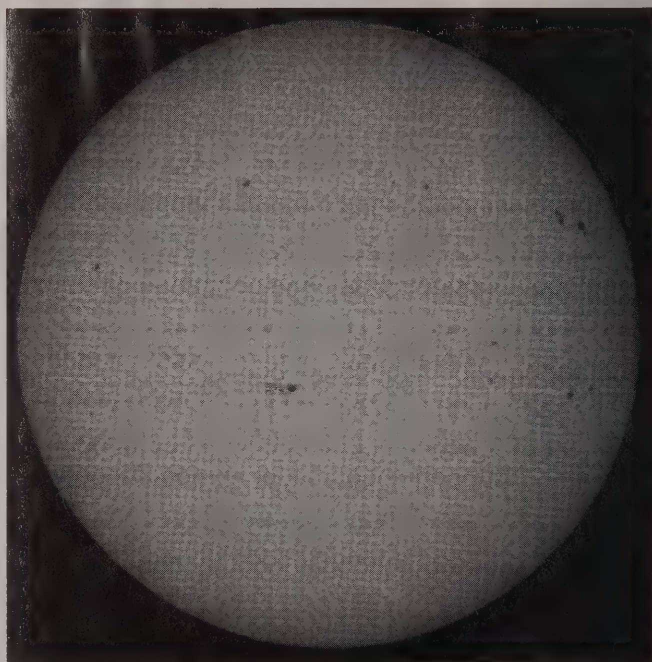


Figure 1. The Sun as seen by the National Solar Observatory (NSO) at Kitt Peak near Cycle 23 solar maximum on April 3, 2000. Note the two bands of sunspots north and south of the solar equator. (Credit: NSO/AURA/NSF)

Old Cycle, New Cycle

Each "new" activity cycle begins at the *minimum* after the preceding solar maximum. Near the minimum, the few remaining "old-cycle" spots are found in their two latitude bands, now very near the solar equator (about 5 degrees north and south).

On the almost spotless Sun, the new cycle begins when spots begin to appear in two *new* bands about 30 degrees north and

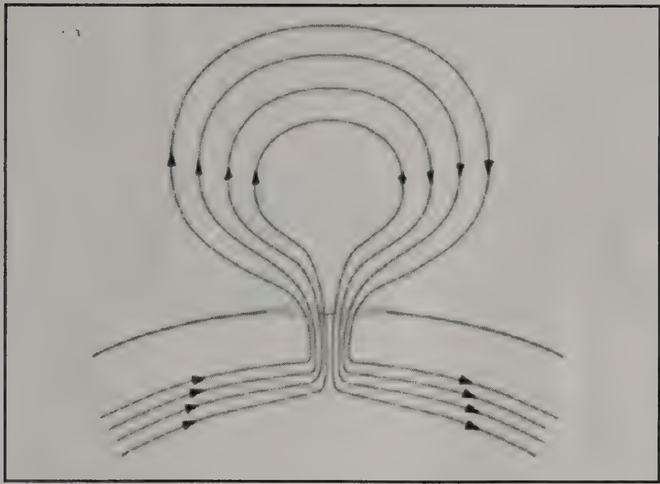


Figure 2. When magnetic-field lines within the Sun erupt through the surface, they form loops creating sunspot pairs. The leading spot at the surface has one polarity and the following surface spot has the other polarity, as indicated by the direction of the arrows.

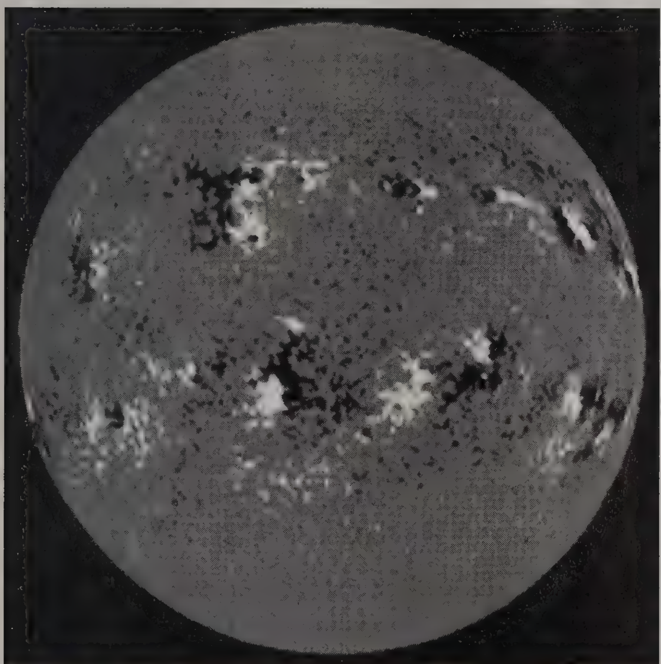


Figure 3. An NSO solar magnetogram, also from April 3, 2000. It shows the magnetic strength at the surface. White is polarity pointing out of the Sun, and black is pointing into the Sun. Note that the northern and southern leading-trailing patterns are reversed. (Credit: NSO/AURA/NSF)

south—with opposite polarities from the old-cycle spots. Thus, the old and new cycles actually overlap each other for a period of time. Their latitude bands and polarities distinguish between the old- and new-cycle spots. Curiously, new-cycle spots generally do *not* appear at the same time in both the Northern and Southern Hemispheres (more later).

As the cycle progresses, the new-cycle spots appear in increasing numbers, with their higher latitude bands slowly moving closer and closer to the equator. By solar maximum, the bands are centered on about 15 degrees north and south latitude. As the cycle wanes, the old-cycle spot count decreases and the two bands move to within about 5 degrees of the equator.

Cycle Strength

The amplitude of a cycle is measured by various indices. The most common one today is the international sunspot index[2], R_i. Another common index is the 10.7-cm radio flux, F10.7. Both indices are quite valid, but have different values. Only R_i will be discussed here, just to simplify the presentation.

Solar Magnetic Cycle

The *activity* cycle, with its sunspots, solar flares, and coronal mass ejections (CMEs) is the result of an underlying cycle of *magnetic* activity within the Sun. The period of the solar magnetic cycle averages about 22 years.

On very large scales, the Sun has a global average magnetic field of about 1 gauss. It is basically a *dipole with its axis passing through the poles.* During solar maximum, every 11 years or so, the polarity of the *polar* field flips direction. As a result, it goes through a complete cycle, pointing from north to south and then back to north again about every 22 years. Each *magnetic half-cycle* produces a peak in solar activity, producing the 11-year *activity* or sunspot cycle.

The magnetic cycle is the result of the recurring evolution of large-scale plasma flows inside the Sun. These flows of charged particles interact to produce a kind of *dynamo.* By concentrating the small overall magnetic field into relatively small volumes, the dynamo produces locally intense magnetic fields, typically a few thousand gauss and sometimes greater than 6,000 gauss. These strong local fields lead to solar activity in the form of sunspots, flares, and other particle and radiant emissions.

Understanding the details of these complex interactions and why they lead to cyclic solar activity has been a "holy grail" in solar physics for a long time. Thanks to the evolution of some very clever technologies, much progress has been made in the last two or three decades in shedding light on these mysterious processes. *Any successful solution to the problem must account for all the effects described above.*

Convection Zone

The outer 30% of the Sun is a seething convection layer. As heat moves up from the fusion core, it reaches a level where the gases are convectively unstable (like the hot air rising in a summer thunderstorm). Giant updrafts within the convection zone carry heat up to the surface of the Sun, where it is released into space. Then the cooled gas sinks back down, to be reheated and rise again.

Since the convection zone is gaseous, it does *not* rotate as if it were a solid object. The equatorial regions rotate faster than the polar regions. Thus, the gases at the equator take about 25 days to rotate all the way around the Sun, but it takes about 35 days near the poles. This effect is called *differential rotation.*

Rising Cycle

At the beginning of a cycle the Sun's whole magnetic field is essentially the polar dipole. However, the lines of force that flow through the Sun, from pole to pole, cannot remain long as simple straight north-south lines. Differential rotation in the convection zone drags the embedded magnetic fields in *equa-*

torial regions westward, out ahead of the same lines of force nearer the poles, eventually wrapping them around in the interior parallel to the equator, like string around an axle (Figure 4).

After a few months, this transforms the north-south polar magnetic field into two east-west *toroidal* field bands, one north and the other south of the equator (figure 4d). These two bands have opposite polarities: one is pointed around in an east-west direction and the other in a west-east direction.

Thus, the reason that the sunspots are found in two latitude bands is that they are spawned from the two toroidal fields that lie beneath the sunspot bands. Eventually, fragments of the toroidal fields float up and break out above the surface in big loops, as shown in Figures 2 and 5. At each foot of the loop is a sunspot, together forming a sunspot pair. Multiple fragments sometimes result in very complex sunspot groups.

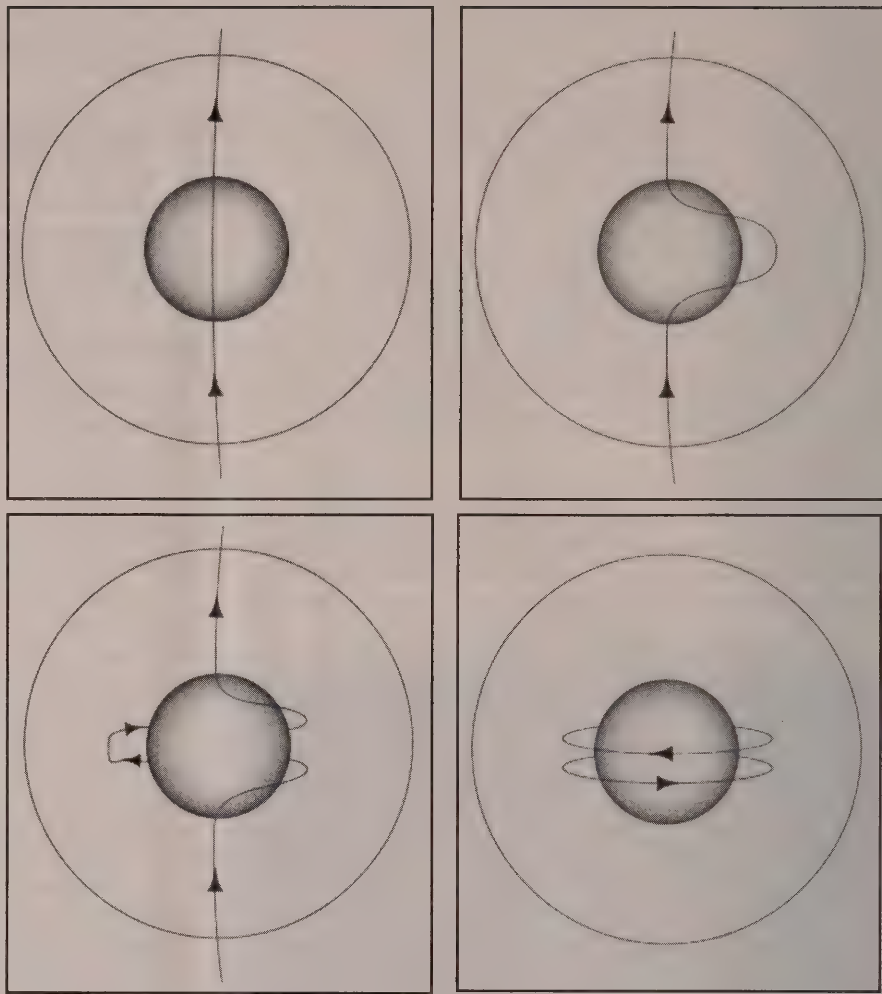


Figure 4. Frames "a" through "d" show how convection-zone differential rotation wraps the polar dipole magnetic-field lines into oppositely sensed toroidal field lines at low latitudes north and south of the equator.

Solar Maximum

As the cycle continues toward maximum, more and more of the polar field is converted into the two toroidal fields, and they and their sunspot bands move closer to the equator. When the toroidal field is at maximum strength, so also is the amount of energy "leaking" upwards into the sunspot-causing above-surface field loops.

Solar maximum occurs when all the available polar-field energy has been converted to the two toroidal fields. At this point, having been sucked down to zero, the polar field passes through zero and *reverses* its polarity to produce a very weak field in the opposite direction. Thus, the *polar-field reversal* is closely associated with the solar maximum.

North Cycle, South Cycle

The northern and the southern polar-field reversals can occur many months apart. The two hemispheres' toroids usually don't reach solar maximum at the same time. One hemisphere often leads the other (see figure 9). This is the reason why new-cycle spots don't appear at the same time in both hemispheres.

Therefore, each hemisphere has its own cycle and timetable. The periods are similar, but the phases are not exactly the same. The two phases shift in time, but they resynchronize from time to time, since they are coupled through their reliance on the same pool of total solar magnetic energy. When the time lag is long between the north and south peaks, a *double-peaked maximum* occurs.

The double peak in Cycle 23 is a consequence of the Northern Hemisphere peak leading the south by about a year. When north and south are *in phase,* a single peak occurs. When they are in phase and both north and south peaks are strong, one gets a powerful cycle, as in Cycle 19 in 1958 ($R_i = 201$)[3]; see Figure 6.

Declining Cycle

Once solar maximum is reached, the respective toroidal fields at the root of the sunspots begin to *weaken,* and the strength of the now-reversed polar field begins to *increase* in strength. The two magnetic toroids continue to move closer to the equator taking their families of sunspots with them, but in ever decreasing numbers.

Finally, as the current activity cycle nears an end and its two magnetic toroids are about to fade out, new toroids appear much farther north and south. The first few furtive spots of a new cycle flash briefly into existence, and nature's cycle begins to repeat. The National Solar Observatory (NSO) saw what was *thought* to be the first unequivocal Cycle 24 sunspot pair on July 23, 2006, but little else has been seen since.

Conveyor Belt

Still, key questions remain. Why does the polar field actually reverse sense and then build up? Why doesn't the activity just remain at maximum for all time after that?

Although the cause is not clear, observations show significant north-south plasma flows in the convection zone between the equator and the poles. There is a large-

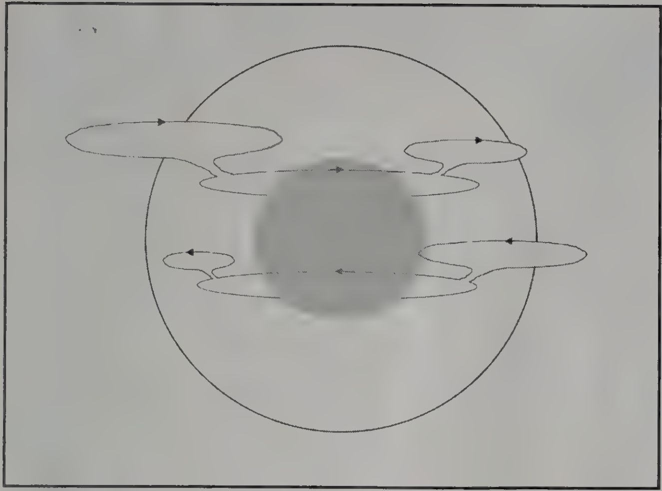


Figure 5. When bulges in the two toroidal field rings become large enough to break through the solar surface, they expand into large loops above the surface and leave a sunspot pair at the points where the field punches through the surface. For simplicity, only one toroidal field-line loop is shown in each hemisphere.

scale upwelling of plasma near the equator that then flows near the surface both north and south toward the poles. Near the poles the gas sinks, and then flows back toward the equator again, now deep in the convection zone. Since these circulation patterns flow along longitude meridians, they are referred to as *meridional flows,* shown schematically in Figure 7.

The meridional flows are the conveyor belts that drive the solar cycle. They drag leftover surface fields from old sunspots toward the poles and then suck them down deep in the convection zone and back toward the equator. These "old" fields will form the *nuclei* for the next generation of sunspots. Curiously, the Southern Hemisphere conveyer belt flow has been running much slower than the Northern Hemisphere flow for a number of years now. This is the apparent reason why the southern polar reversal has trailed the north for the last two or three cycles.

The Sun's Magnetic Memory: It takes 30 to 50 years for the conveyor belt to make one complete circuit. Since the new-cycle spots reappear at about 30 degrees latitude, they only ride the conveyor part way around. Even so, it takes something like twenty years before some of them reappear. Thus, the "remembered" field fragments from at least the last two cycles (and maybe more) "seed" the current cycle's sunspots and active regions.

Predicting Cycles

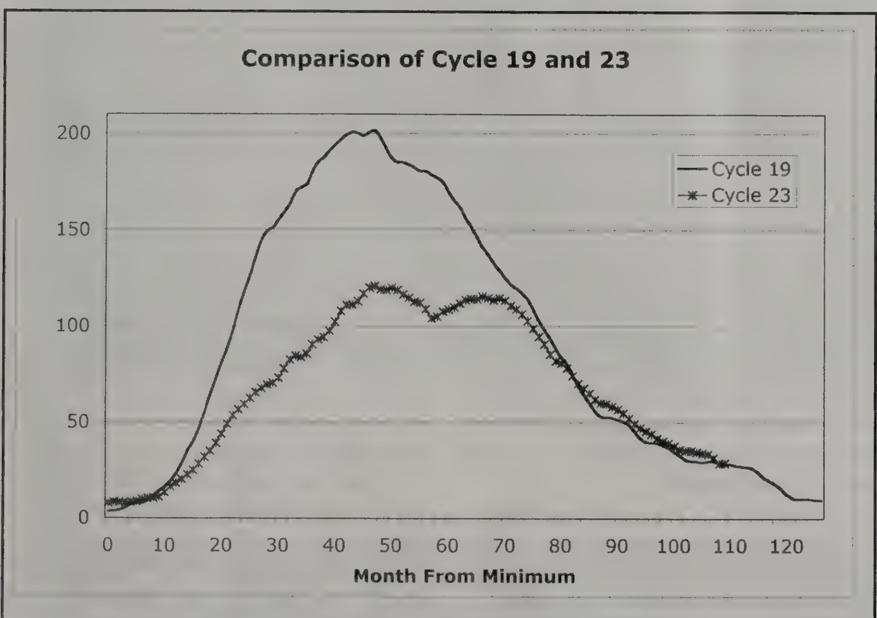
Since the past history of solar activity seems to play a role in the evolution of future activity, today it is reasonable to assume that one could find ways to make accurate long-range forecasts.

This has been an underlying assumption in past prediction efforts as well. However, without understanding how the past and future were *physically* connected, there has been much disagreement about which of the measurable characteristics are the most important.

In principle, there are two broad approaches to predicting future solar cycles, statistics and physics. The parameters one might predict would include: the maximum amplitude of the cycle (e.g., the smoothed sunspot number Ri), the date of the peak, and the length of the cycle. Table 1 shows some actual values from the last five peaks.

Until the last couple of cycles, very little was directly known about the details below the visible surface of the Sun, simply because those regions could not be seen or measured. For decades the only prediction approaches were based on statistical relationships seen in previous cycles. This still remains the most common approach today. However, today there is one novel method that applies actual solar interior data to a physical model of the Sun's interior structure.

Currently there are more than twelve different published professional predictions of the characteristics of Cycle 24; almost all are of the statistical variety. These various methods produce answers that range from a very strong maximum, perhaps a year earlier than expected, to one of the weakest on record—and everywhere in between.



Statistical Methods

One approach is to amass a database of the solar and terrestrial observables from as many past cycles as possible. These might include the length of the cycle, the rate of rise and fall of the cycle amplitude, peak amplitude of cycle maximum, amplitude and polarity of the global field, intensities of the local magnetic fields, and various geomagnetic indices.

Then, one could look for statistical correlations among these different factors in different cycles. If a dependable set of correlated factors were found, then

Figure 6. Cycles 19 and 23, respectively, are good examples of single- and double-peaked cycles. Notice the delay in even the first peak of Cycle 23 with respect to Cycle 19.

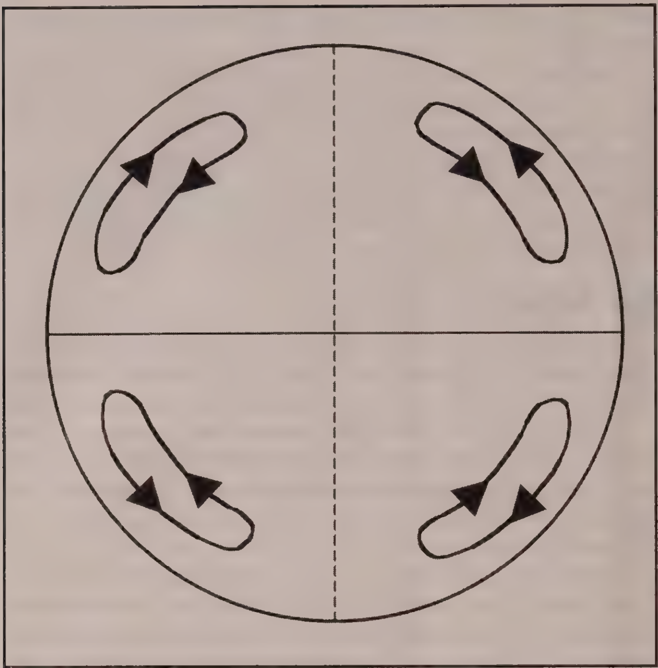


Figure 7. The meridional circulation currents of near-surface plasma from the equator to the poles trap residual magnetic fields from "dead" sunspots that are recycled into future solar cycles, perhaps one to three cycles later.

Figure 8. A GONG "image" of near-surface active regions on the Sun's far side. Clever data processing of seismic waves within the Sun permit this "x-ray" view through to its far side. The large feature on the right just below the equator emerged as a nearside sunspot group four days later. (Credit: GONG/NSO/AURA/NSF)

one could use those relationships to predict the values of a future cycle.

The 240-Year "Cycle." As an example of a *statistical* approach, there seems to be a pattern in the solar cycle *lengths* with a period of roughly 240 years. With some fluctuations, cycles tend to get shorter for about 120 years, then tend to get longer for about 120 years, and then the pattern appears to repeat. Since Cycle 14 (beginning in 1902) the trend generally has been toward shorter cycles.

Weighted Averages. Another straightforward example of the statistical approach is that of John Kennewell at Australia's IPS Radio and Space Services. He currently uses a system based on weighted averages of the characteristics of a few recent cycles.

Wilson's "Rule." Predicting the date of the next maximum could also depend on the date of the *preceding minimum.* Known as "Wilson's Rule," recent solar cycle minimums usually occurred about 34 months *after* the first full day with *no visible spots* on the Sun.

Dave Hathaway, at NASA's Marshall Space Flight Center, notes that the first spotless day of Cycle 23 occurred on January 28, 2004. Based on Wilson's Rule, the Cycle 23 minimum should have occurred in November or December 2006. This date is consistent with the recent trend toward short cycles, mentioned above. However, the minimum did *not* occur in 2006. If it had, it would have suggested that the Cycle 24 maximum would occur in late 2010.

Four Years After Minimum. The solar minimum date is also important because the next maximum usually occurs about four years after the minimum. In any case, almost all prediction methods get pretty good once the new cycle actually starts and some real data starts to accumulate.

Precursor Methods

Several seasoned researchers hold that the *precursor* prediction methods are among the best. These methods are based on the hypothesis that the configuration of the Sun during one cycle determines the major features of the Sun during either the next cycle or the one after that. Without access to the details of the Sun's current internal configuration, precursor methods look for gross measurable indices as "proxies" for the real physical details.

Geomagnetic Precursors. Some of these methods rely on variations of the geomagnetic aa[4] index at the preceding solar minimum as a predictor of the following maximum, such as one by Joan Feynman at NASA's Jet Propulsion Laboratory. Richard Thompson, recently retired from IPS Radio and Space Services in Australia, uses the number of days during the previous cycle that the geomagnetic field was disturbed. More recently, Hathaway and Wilson have developed a hybrid method that incorporates parts of both the Thompson and Feynman approaches.

Cycle	Date Max	R_i Max
19	Mar. 1958	201
20	Nov. 1968	111
21	Dec. 1979	166
22	July 1989	159
23	Apr. 2000	121
24	?	?

Table 1. Comparison of recent cycles.

Solar Precursors. Some time ago, Ken Schatten, at Ai-Solutions, Inc., constructed an index relating to the Sun's buried dynamo fields. He assumed that if geomagnetic effects have some prediction success, then actual solar magnetic fields measurements should work even better. He uses an index that tracks the total magnetic field, including both the polar and toroidal components. Leif

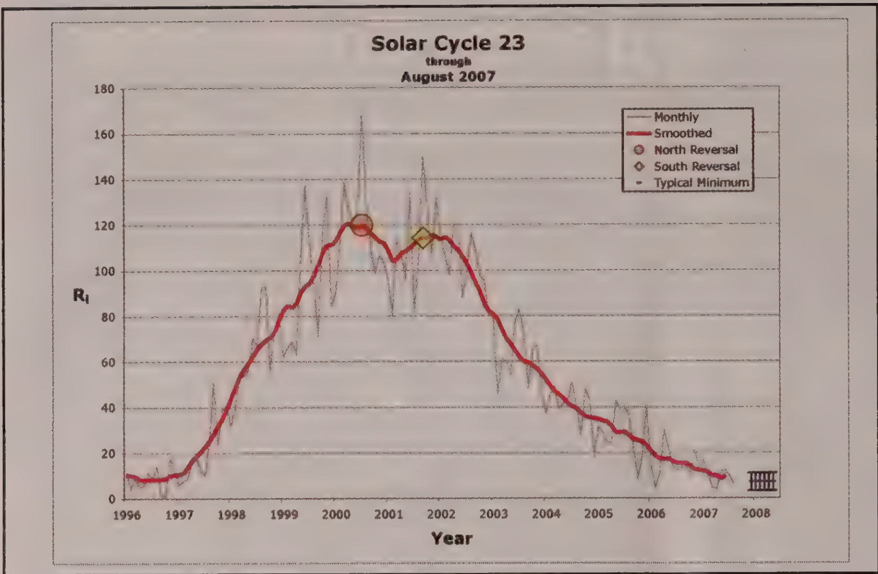


Figure 9. This plot of the Cycle 23 R_i overlays the monthly and 12-month running-average smoothed values. The shaded circle and diamond show the points of north and south polar-field reversal, respectively. The line with error bars in the lower right corner shows the mean and one sigma range of the smoothed R_i as seen at solar minimum for the last 100 years.

Svalgaard, at ETK, uses a somewhat similar method based only on the polar field strength at solar minimum.

Magnetohydrodynamic Models

Developments permitting actual observation of the *interior* of the Sun are beginning to offer intriguing new possibilities in solar cycle prediction. The study of helioseismology uses sound waves, traveling through the inside of the Sun, to visualize the structure and dynamics of the solar interior, something like a medical CT scan. Collaborative research projects at the National Solar Observatory[5] and Stanford's Wilcox Solar Observatory[6] have collected a full solar cycle of data on the evolution of the Sun's internal structure.

These techniques have yielded many key pieces of information in understanding the processes that take place inside our nearest star. They also have led to practical short-term predictive tools, including the visualization of active regions on the far side of the Sun, away from the Earth. This is enabling prediction of when new or returning activity will rotate back into view and become geoeffective (Figure 8).

Armed with these and other data, one could construct magnetohydrodynamic predictive models that start from first principles, the *physics* of the Sun itself. One such model has been developed by Mausumi Dikpati and her collaborators at NCAR's High Altitude Observatory. While still being fine-tuned, they insert structural data from previous cycles in a computer model of the flow interactions, and predict what a subsequent cycle should look like. It has been very successful in reproducing previous cycles, including the double maximum in Cycle 23.

This sort of approach might be quite accurate at predicting one or two cycles in the future. However, there is an important caution. There is good reason to believe that the fine details of the solar flows are basically chaotic processes.

Thus, like the weather on Earth, short-term predictions might be fairly accurate, but longer term predictions would be progressively less reliable.

Hindcasts and Forecasts

No matter what kind of method or model one uses, the fine tuning of the approach is based on applying the scheme to *past* cycles, where "what happened" is already known, and then adjusting the details for the best match. This is a process known as *hindcasting*. Most methods work pretty well when you already know the answer! In the past, the use of those methods to *forecast* has met with very mixed results.

Who to Believe?

Table 2 shows a comparison of the predictions by six respected forecasters and a consensus committee. These are samples of the available methods, chosen to reflect the diversity of predictions based on the various general approaches. The dates are approximate and the activity predictions range from awful to terrific. (The same has been true of past predictions for previous new cycles.)

In the current case, the two solar precursor methods are making very pessimistic predictions, while the two geomagnetic precursor methods are making optimistic predictions.

One would think that the solar precursor methods, based on parameters closer to the root source—the solar magnetic field—would be more reliable. However, the Dikpati model, *if correct,* should be the most accurate. Curiously, it disagrees with the solar precursors shown and produces the most optimistic prediction of

Lead Researcher	Method	Cycle 23 Min. Date	Cycle 23 Min. R_i	Cycle 24 Max. Date	Cycle 24 Max. R_i
Dikpati	Flux Transport Dynamo	Late 2007–Early 2008	—	Jan. 2012	169 ±12
NOAA Committee	High Consensus	Mar. 2008	—	Oct. 2011	140 ±20
Kennewell	Recent Cycle Statistics	Oct. 2007	8.5	Aug. 2011	134 ±50
Schatten	Solar Precursor SODA Index	—	—	Oct. 2011	100 ±30
NOAA Committee	Low Consensus	Mar. 2008	—	Aug. 2012	90 ±10
Hathaway	Super Geomag Precursor	Aug.–Sept. 2006	7.2	Jun. 2010	147 ±24
Wilson	Wilson's Rule	Nov.–Dec. 2006	—	Nov.–Dec. 2010	—
Svalgaard	Solar Precursor Polar Field	Oct. 2006	—	2011	75 ±10

Table 2. Comparison of several prediction methods.

all, even exceeding those of the geomagnetic methods. Whatever actually happens, we should learn something.

The NOAA Committee. The National Oceanic and Atmospheric Administration convened a committee of experts to try to reach a consensus prediction. In late April 2007, the committee issued a report saying that they were evenly split into two camps. One group steadfastly believes that the cycle will be good (but not great), and the other group feels that it will be a rather poor cycle. The only thing they agreed on is that the minimum was likely to be about March 2008.

It is also important to note that the last three predictions in Table 2 have already failed to predict the solar minimum date. At this writing (September 2007) it seems unlikely that solar minimum occurred *before* August 2007.

Beware the Error Bars

Another caution about predictions is their error estimates. They are often quite large. Each method is predicting not one value, but a *range* of values. For example, a value of $R_i = 150 \pm 50$ might appear to predict a fairly good cycle. However, it actually predicts Ri to be anywhere between 100 (a very poor cycle) and 200 (a rival of the amazing Cycle 19).

Predictions with large error bars reflect a lack of confidence in the precision of the method's predictive capability (usually based on previous experience). In any case, large error bars don't provide a very precise *quantitative* or *qualitative* picture of the predicted activity.

A Reality Check

As noted, there was a brief appearance of what appeared to be new Cycle 24 activity in mid and late 2006. However, this hopeful flurry of activity quickly dissipated. Figure 9 shows the progress of Cycle 23 from the previous minimum in 1996 through August 2007. The slope of the smoothed R_i was clearly still negative.[7]

The shape of the plot suggests that the curve may round out to reach minimum by late 2007. However, if R_i minimum is much lower than 10, it could even be Dikapti's prediction of early 2008.

When Will the DX Start?

From a DX perspective, the crucial question isn't "When is the solar maximum?" Rather, it is "When will solar activity be high enough for good propagation?"

R_i	NOAA Panel Low	Recent Statistics	NOAA Panel High	MHD Model
Minimum	Mar. 2008	Oct. 2007	Mar. 2008	Jan. 2008
60 – TEP	**Dec. 2010**	**Aug. 2009**	**Dec. 2009**	**Aug. 2009**
100 – E/W F_2	**—**	**Sept. 2010**	**Dec. 2010**	**Jun. 2010**
134	—	Oct. 2011	Oct. 2011	Mar. 2011
147	—	—	Mar. 2012	June 2011
169	—	—	—	Jan. 2012

Table 3. Possible Figure 10 dates.

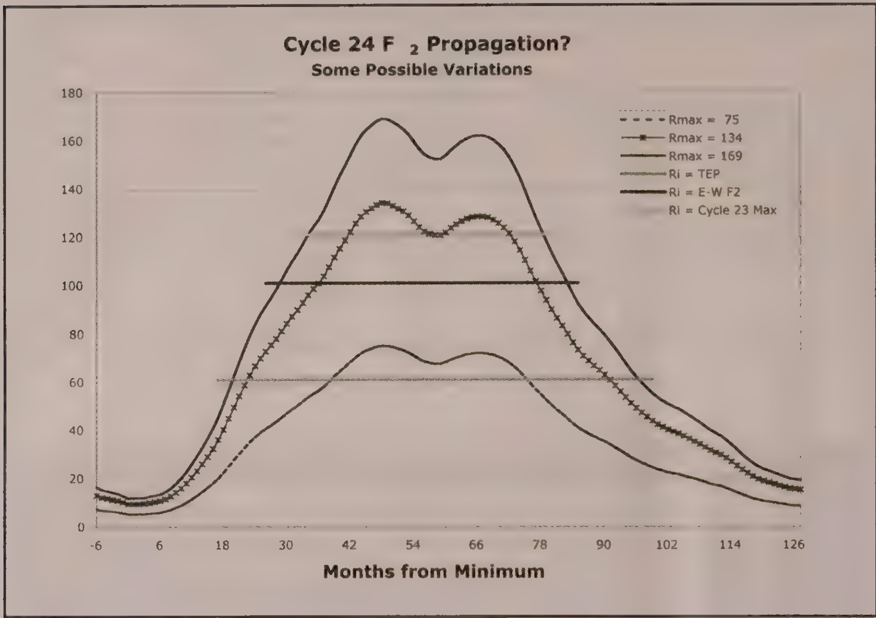


Figure 10. These are three realizations of an R_i model scaled to the maximums predicted by Svalgaard, Kennewell, and Dikpati, respectively. It assumes that the slowdown in the Southern Hemisphere meridional flow "conveyer" will lead to another doubled-peaked maximum, much like Cycle 23. It shows the time relationship between the preceding minimum and the onset and duration of Cycle 24 TEP at R_i about 60, east-west F_2 at about 100, and the period above Cycle 23 at R_i = 121.

My own experience shows that once the smoothed R_i rises above about 60, the MUF will regularly start peaking above 50 MHz—subject to the usual seasonal effects (i.e., *no* TEP [transequatorial propagation] in the summer and winter, and *no* F_2 during local summer). This generally will show up first as north-south TEP, taking advantage of the ionization boost of the equatorial anomaly. As R_i rises to about 100, east-west F_2 will also start to show up. Depending on the cycle strength, TEP and linked TEP can start as early as about 18 month after *solar minimum,* and east-west F_2 about a year after that.

To illustrate this, Figure 10 shows an example of three different *possible* Cycle 24s. The current evidence is that the slowdown in the southern meridional flow, which probably led to the double peaks in Cycles 22 and 23, is continuing. Thus, the shape of the curves is based on a highly smoothed version of Cycle 23 and is identical in each case, except for the scale factor. The curves are then scaled to the maximum R_i predicted by Svalgaard, Kennewell, and Dikpati and shown in Table 2.[8] Notice that the higher the maximum value of R_i the more rapidly the propagation thresholds are reached.

These were chosen as representative examples of low, medium, and high cycles. Note that all the curves are *based on the date of solar minimum,* not a calendar date.

While no representation is made for the detailed accuracy of the figure 10 models, if one focuses narrowly on the date of the onset of propagation, once the actual date of solar minimum is established, the models should be useful in tracking toward the start of good propagation.

The time between the previous minimum and the new maximum is right about four years, based on many previous cycles. With the actual minimum date and an estimate of the R_i at maximum, even a straight line drawn from the minimum to the maximum R_i four years later will be a good estimate of the ramp up of activity in between those two dates, *if* the maximum R_i estimate is about right. Figure 10 gives three choices that bracket the range of R_i maximum predictions.

Now, to restore some possible *dates* to figure 10, one can take the solar minimum dates of the corresponding maximum R_i predictions in Table 2 and project the dates at which various values of R_i might occur (using figure 10). The results are shown in Table 3. The values in bold show the dates R_i would reach the TEP and E-W F_2 levels. Of course, to be more realistic, one

must take into account the seasonal patterns of these propagation modes. Applying these, the range of starting dates is:

- **TEP: Fall 2009 or Spring 2010** (except for the NOAA low, Spring 2011)
- **E-W F_2: Fall/Winter 2010**

It is interesting that even though they predict different minimum dates, the three more-optimistic models all seem to converge on about the same starting seasons for each of the TEP and F_2 propagation. This is a result of the interplay between the minimum dates and the different rates of R_i rising toward maximum.

These are just examples, not really predictions (and remember the error bars, too!). The real point here is that unless the cycle is very poor, the DX will start *before* the maximum.

So when will the DX really start? We'll have to wait and see. However, we don't have to wait passively.

Once the minimum is reached and the rising phase of the cycle gets under way, one can begin plotting the monthly R_i values over the figure 10 curves and get a sense of which of the rising curves they are actually on. After several months the pattern will probably emerge and one can then get a sense of *when* and *what* will happen.

Cycle 25 and Beyond

Some people are even beginning to think about Cycle 25. One interesting factor is the 240-year pattern of shorter and longer cycles. If this pattern in previous data is real, the exact length of the period still is not precisely known.

If it really is pretty close to 240 years, then Cycle 23 should be a *short* cycle. But, it *exceeded* 11 years in May 2007, and at this writing we don't know when it will end. We still don't have clear signs of the Northern Hemisphere new cycle kicking in, and it would be expected to start *before* the start in the Southern Hemisphere.

All this is consistent with several of the predictions in Table 2, and with the observation that the Southern Hemisphere meridional conveyor belt is slowing down. It is also consistent with the notion that the 240-year pattern is either shorter than 240, or it is starting a few years early. If so, then Cycle 24 and Cycle 25 will likely be long cycles.

Acknowledgements

The author appreciates comments and suggestions by Jack Harvey at NSO, and the graphics skills of Kirk Pu`uohau-Pummill at Gemini in producing the renderings for Figures 2 and 4. The sunspot data used here are from the compilations by the Solar Influences Data Analysis Center (SIDC) at the Royal Observatory of Belgium (www.sidc.be).

Notes

1. *50 MHz F_2 Propagation Mechanisms,* Kennedy, J. R., 2000, in *Proceedings* 34th Conference Central States VHF Society, (ARRL Pub. 257), 87–105.
2. The value of R_i is essentially the same as the historical R_z (Zurich) sunspot index, by deliberate design.
3. See: www.ips.gov.au/Educational/2/3/1.
4. This index is derived from the three-hour averages of the *K* index at two antipodal Earth-based observing stations.
5. The Global Oscillation Network Group (GONG).
6. The Michelson Doppler Imager (MDI) experiment on the SOHO spacecraft.
7. For the last few data points only, the smoothing span has been shortened from the traditional 12 months.
8. Note that these models are *not* the detailed models of Svalgaard, Kennewell, and Dikpati, but different models merely scaled to their nominal predictions for the maximum R_i.

Amateur Radio and the International Geophysical Year 1957–1958

Fifty years ago the International Council for Scientific Unions (now known as the International Council for Science, or ICSU) oversaw an 18-month period of worldwide scientific exploration and research known as the International Geophysical Year, or IGY. Amateur radio operators were invited to participate in the research as it related to propagation. Here WA2VVA documents some of the amateur-radio-related research that took place during the IGY.

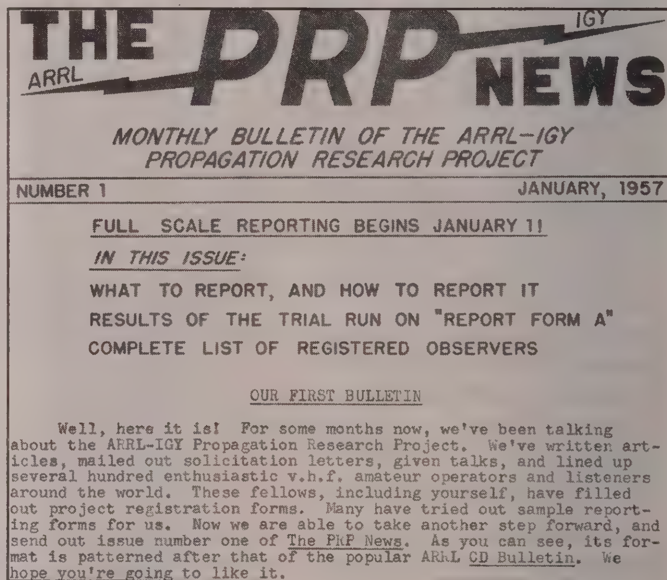
By Mark Morrison,* WA2VVA

The International Geophysical Year (IGY) was an 18-month period starting in July 1957 and ending in December 1958. Timed to coincide with the peak of the 11-year sunspot cycle, it was a cooperative effort of scientists, amateur as well as professional, from around the world.

Unlike most scientific endeavors, unskilled observers were invited to take part, the idea being that if competent people could be organized to make coordinated observations around the world, the amount of data collected would be that much greater. "Project Moonwatch" was the name given a satellite-tracking program using amateur astronomers to visually track the artificial satellites launched during the IGY. A separate program named "Project Moonbeam" invited amateur radio operators to track these same satellites using radio equipment not uncommon in many radio shacks of the era. The November 1957 issue of *QST* published the official invitation made by Dr. Pickering of the Jet Propulsion Lab.

> Over the past year and a half *QST* has carried a number of articles describing various sections of the Minitrack system of satellite tracking as developed at the Naval Research Laboratory. The NRL activity is part of the work of a special group in the U.S. National Committee for the IGY. Dr. Pickering, head of this Working Group on Tracking Computation, issues here an official invitation to qualified amateur groups to participate in the volunteer satellite-tracking program—now known as "Project Moonbeam."

Through the efforts of the ARRL, which coordinated amateur radio activities through its "Propagation Research Project," VHF enthusiasts also collected data on various modes of VHF propagation, including aurora, meteor scatter, transequatorial and sporadic-*E*. A special newsletter called the "PRP News" published reports of significance and useful information for "PRP Observers," including beacon frequencies, identification of special observing days called the "world days," and myriad other items of interest. Figure 1 is a reproduction of the first issue.


THE ARRL PRP IGY NEWS

MONTHLY BULLETIN OF THE ARRL–IGY PROPAGATION RESEARCH PROJECT

NUMBER 1 — JANUARY, 1957

FULL SCALE REPORTING BEGINS JANUARY 1!

IN THIS ISSUE:

WHAT TO REPORT, AND HOW TO REPORT IT

RESULTS OF THE TRIAL RUN ON "REPORT FORM A"

COMPLETE LIST OF REGISTERED OBSERVERS

OUR FIRST BULLETIN

Well, here it is! For some months now, we've been talking about the ARRL-IGY Propagation Research Project. We've written articles, mailed out solicitation letters, given talks, and lined up several hundred enthusiastic v.h.f. amateur operators and listeners around the world. These fellows, including yourself, have filled out project registration forms. Many have tried out sample reporting forms for us. Now we are able to take another step forward, and send out issue number one of The PRP News. As you can see, its format is patterned after that of the popular ARRL CD Bulletin. We hope you're going to like it.

Figure 1. This is the first page of the first issue of the "PRP News," a special newsletter that published reports of significance and useful information for "PRP Observers."

The propagation data collected through the "PRP News" was to be analyzed by PRP staffers and the U.S. Air Force through its Cambridge Research Center. Looking for patterns in monthly heard and worked reports, it was hoped that new discoveries might be made, particularly with regard to transequatorial propagation. This mode of propagation was discovered by radio amateurs in 1947 and was a major reason for recruiting them during the IGY.

The PRP expressed interest in all forms of propagation save one—tropospheric ducting. Yet it was via tropospheric ducting that arguably the greatest amateur accomplishment of the IGY took place.

From "PRP News" January 1957:

What We're Not Interested In

Reports of ground-wave work out to 75 or 100 miles will not be of use in PRP. Likewise, we are not concerned with contacts made by tropospheric propagation. This includes those due to air mass boundary bending and duct effects caused by the changing weather pattern, and those due to scattering from the troposphere. Either of these will provide contacts out to perhaps 500 miles, the former with irregular, strong signals, and the latter with consistent, weak ones. Since we are studying ionospheric propagation only, reports of such tropospheric work are not solicited.

*5 Mount Airy Road, Basking Ridge, NJ 07920
e-mail: <mark1home@aol.com>

Amateur radio was well represented at the XII General Assembly of the International Scientific Radio Union (URSI) held at the University of Colorado Aug. 22 — Sept.

This group, in front of the University Memorial Center in Boulder, includes, left to right, Tilton, ARRL, W1HDQ; Dickson, USA Signal Propagation Agency, Ft. Monmouth, N. J., K2HJU; Booker, K2SKB, son of Dr. Booker of Cornell; Dieminger, Max-Planck Institut for Physik des Ionosphare, DL6DS; Burbank, USN Electronics Lab., San Diego, W6CDF; Moore, Univ. of N. Mex., W5WBZ; Dinger, NRL, W3KH; Peterson, Stanford, W6POH; Menzel, URSIGRAM Committee, Geneva, Switz., DL1UR; Seddon, National Academy of Science, Wash., D. C., W4SBQ; (kneeling) Silberstein, NBS, Boulder, WØYBF; Herbstreit, NBS, Boulder, WØIIN; Johnson, Dartmouth, W1FGO; deBettencourt, Pickard and Burns, Inc., W1CXJ.

Other amateur delegates to the Assembly, not present for the picture, included Dyce, Stanford, W2TTU/6; Carpenter, NBS, Wash., D. C., W3OTC; Cumming, Wilton, Conn., W1FB; Kirby, NBS, Boulder, WØLCT; Menzel, Harvard, W1JEX; Rohdin, Royal Board of Telecommunications, Stockholm, SM5FD; Swenson, Univ. of Illinois, K9ESK; Morgan, Dartmouth, W1HDA.

Seven of the above are QST authors.

Photo 1. From November 1957 QST, *this is a photo of amateur radio operators who attended the XII General Assembly of the International Scientific Radio Union (URSI) held at the University of Colorado from August 22 to September 5, 1957. (Photo courtesy of the ARRL and* QST *magazine)*

At a time when aurora and meteor scatter dominated the VHF DX scene, few considered tropospheric propagation of much value. Most considered meteor scatter or sporadic-*E* the best modes for long-haul operations. Either way, operators from around the world took advantage of the IGY to reach for new VHF distance records. Indeed, with the number of hams expected to participate during the forecasted favorable conditions of the forthcoming sunspot cycle, it was just a matter of time before someone hit it big. This entry in "PRP News" shows that Australian operators were looking to bridge the Pacific on 6 meters and possibly even 2 meters:

Here are two well-known v.h.f. ops -- Joe and Hal Taylor, K2ITP and K2ITQ, of Riverton, New Jersey. Hal is seated before the receiving gear (6AK5-404A converter into S-40B), while Joe stands alongside the closet wherein resides a 4-250A rig run at 700 watts c.w., 650 watts AM phone and 1 kw. SSB. The antenna is a 5-over-5 spaced 5/8 wavelength and 65 feet above ground. That array of certificates (including two PRP Consistent Reporting Awards) and 50-Mc. DX cards speaks for itself!

Photo 2. From August 1958 "PRP News," this is a photo of Hal (seated) and Joe Taylor at their ham station.

Transpacific Anyone?

Norman Burton of 143 The River Road, Revesby, NSW, Australia sent us a very interesting letter recently with an eye toward establishing schedules between Australia and the U.S. west coast on 5/6 and 2 meters. Norman passes along word of verified reception of the BBC-TV sound channel (41.5 Mc. In London) in Australia. This makes him feel that 5 meter work (the Australians use 56 to 60 Mc.) is a certainty over the path he suggests, and 2 meter work a distinct possibility.

What Norman would like to see is automatic or scheduled 50.5 Mc. transmissions beamed on Sidney from our west coast. He says that on or about February 1, there will be two beams on the San Francisco area every day from "down under." More observers may be added later on, as may 5 meter transmissions, and eventually, 2 meter attempts.

Anyone interested in getting in on this work is invited to get in touch with Norman at the above address. We will also pass along any information that comes this way.

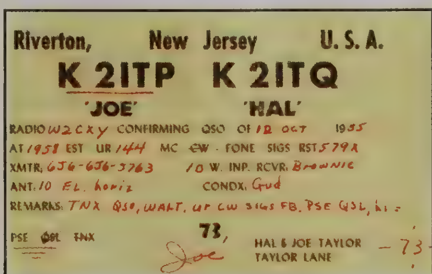


Photo 3. Hal and Joe Taylor's common QSL card.

Although many significant radio contacts were made during the IGY, including transequatorial contacts between the Northern and Southern Hemispheres, it was a lone tropospheric contact that broke all the records. After eight months of schedules with little to show for it, the persistence of Ralph "Tommy" Thomas, W2UK/KH6UK, and John Chambers, W6NLZ, finally paid off when their 2-meter signals spanned 2500 miles of the Pacific Ocean on July 8, 1957. This historic QSO, which practically doubled the 2-meter DX record of the time, is arguably the greatest amateur achievement of the IGY.

News of the big event spread quickly and was widely publicized not just in *QST*, but in the "PRP News" as well. From "PRP News":

Although you must have already either read or heard the following information, we thought we'd mention it here because it is so

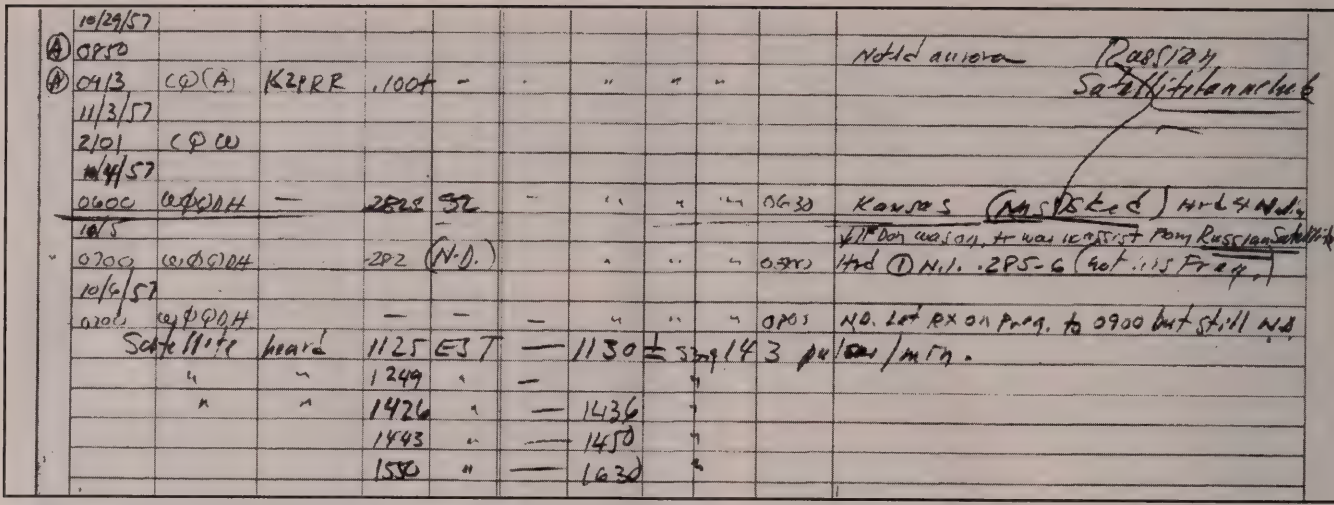


Figure 2. An excerpt from the logbook of W2CXY. Such excerpts were the basis of the reports published in the "PRP News."

very noteworthy. On July 8th, W6NLZ and KH6UK set a new DX record of about 2540 miles with their 2-meter contact. The QSO took place between 2211 and 2227 PST. Quite a haul! An interesting point is that a check of report forms show that sporadic-*E* skip was absent from the 6-meter band at this time, so some sort of tropospheric super inversion was probably the cause.

The fact that the ARRL used 6-meter reports, or the lack of them, to rule out the possibility of a sporadic-*E* contact is very interesting, because Tommy, KH6UK, once considered the same thing in reverse. In an audio letter to W2CXY Tommy put it this way:

> I had hoped to do some work on 6 in conjunction with 2 meter experiments as I thought maybe if I could pick out the periods when 6 was open from sporadic-*E* we might be able to do something on 2 at that time.

This plan was defeated, however, by local interference from the RCAC transmitters in Kahuku. Even so, Tommy and John continued their schedules and scored a second QSO a month later. From "PRP News" September 1957:

> **More California to Hawaii on 144**
>
> Remember that 2 meter contact between W6NLZ and KH6UK that took place on July 8th? A new DX record of about 2540 miles was set. Well, they did it again! On August 18th at 1800 HST, KH6UK's automatic transmission was heard by W6NLZ. Signals were weak and fading until 1850 and the contact lasted through until about 1915. Your report forms for the second half of August haven't started to arrive yet, so we are unable to get an idea of what was happening on the band at that particular time. This California-to-Hawaii haul is beginning to look promising!

Radio Propagation and Atomic Bomb Tests
Amateur Observations Wanted

In the course of the current series of atomic bomb tests at the Nevada Proving Grounds, many reports of peculiar radio propagation effects have come to ARRL. Some appear to be mere coincidence, but others indicate that there may be definite effects on wave propagation, particularly on paths that cross the area of the tests. If such effects exist, we'd like to know more about them, and so would a number of physicists working in the wave propagation field.

We ask, therefore, that amateurs noting unusual propagation, radio noise, or other effects that might be associated with bomb explosions, report their observations in detail to ARRL. We will see to it that the reports reach the people who are interested in studying them. Simply send such information to the Technical Department, ARRL, West Hartford 7, Conn.

Photo 4. From November 1957 QST, *this is a copy of the recruitment announcement for amateur radio operators to observe the potential effects of atomic-bomb blasts on radio propagation. (Photo courtesy of the ARRL and* QST *magazine)*

In August 1957 scientists of the International Scientific Radio Union (URSI) met in Boulder, Colorado to discuss radio matters related to the IGY. This excerpt from the October 1957 "PRP News" shows that the KH6UK/W6NLZ contact received more that just a passing interest.

> **The U.R.S.I. General Assembly**
> **A Brief Report**
> *By E. P. Tilton, W1HDQ*
> *VHF Editor of* QST
>
> Late in August your VHF Editor had the pleasure of attending the XII General Assembly of the International Scientific Radio Union (URSI) at Boulder, Colorado. The first worldwide meeting of URSI to be held in this country since 1927, it was probably the most important and widely attended of any. Top-level scientists from at least 26 member countries took time out from their heavy IGY schedules to come to Boulder and discuss their mutual problems. To have been privileged to sit in on their informal discussion and technical sessions was an experience this reporter will not soon forget.
>
> Hearing these world-renowned physicists talk shop presented a fine opportunity for sensing the great potential worth of our ARRL Propagation Research Project for the IGY. The world's wave propagation problems are far from solved, and again and again we ran across areas of conjecture where amateur operations may provide useful evidence that would be obtainable in no other way. There was great interest in the record 144 Mc. work of KH6UK and W6NLZ, for example. Dozens of delegates to the Assembly came to the writer to get more information on it. Without exception, these people voiced the strongest praise for amateur work of so high an order.
>
> There was much talk of transequatorial scatter, the ham-discovered phenomenon that largely was responsible for our entry into the IGY picture originally. The worth of amateur observations in the study of this, and in learning more of auroral and sporadic-*E* phenomena, was reaffirmed by many.

One of the hams who attended the conference was a scientist with direct involvement in the IGY. This press release

from Dartmouth College describes the contribution of Dr. Millet G. Morgan, W1HDA, during the IGY:

> During the International Geophysical Year (IGY, 1957–8) Prof. Morgan chaired the US National Committee's Panel on Ionospheric Research of the National Research Council, which oversaw radio studies conducted all around the earth. In early 1958 he joined the re-supply mission to the US Antarctic station on the Weddell Sea as the senior scientific representative. In his own IGY research he maintained an extensive series of stations throughout the Americas.

Photo 1 is from November 1957 *QST*. The picture shows some of the people who attended the conference. Note that Dr. Morgan is listed as one of the delegates.

Other hams were scientists who contributed to the IGY in different ways. Dr. John Kraus, W8JK, inventor of the helical antenna and well-known radio astronomer of Ohio State University (OSU), was mentioned regularly in the "PRP News." His circularly polarized antennas, now standard equipment on all major space missions, were of considerable interest to VHF enthusiasts pondering "moon reflection" work during the IGY. Many amateurs wrote to Dr. Kraus asking for advice and he kindly replied. Dr. Kraus played a significant role in tracking the first satellites using his radio astronomy telescope.

Still other hams were just teenagers during the IGY but went on to become respected scientists in their own right. Two regularly mentioned in the "PRP News" were brothers Joe and Hal Taylor from New Jersey. Both were serious operators on the VHF bands. Hal, K2ITQ, received a PhD under Dr. James Van Allen, the University of Iowa scientist who originally conceived of the IGY. Hal went on to became a professor of physics at The Richard Stockton College of New Jersey, where he taught for more than 30 years. Hal became a Silent Key in 2002, succumbing to cancer.

Joe, K2ITP, now K1JT, received the Nobel Prize for his work with binary pulsars and is more recently recognized as the Princeton physicist who revolutionized meteor-scatter and moonbounce operations with his WSJT signal-processing software. Using this software, it now is possible for radio amateurs to make meteor-scatter contacts practically any time of the day or night.

Photo 2 from the August 1958 "PRP News" shows Hal and Joe at their station. Photo 3 shows their joint QSL card.

October 1957 was an exciting month for the IGY, as the Soviet Union launched Sputnik, the world's first artificial Earth-orbiting satellite. Long before this launch amateur radio publications in the U.S. (*QST*) and Russia (*Radio*) prepared operators for what to expect. The Russians would use 20 and 40 MHz for Sputnik, while the U.S. would use 108 MHz. For some reason, the official U.S. ground stations were not prepared to monitor Sputnik when it was first launched, so amateur operators provided listening reports until they could be changed to the lower frequency. Many PRP observers recorded such reports in their logbooks and sent reports to the "PRP News." Figure 2 is an example from the logbook of W2CXY.

Using PRP reports such as this one, and knowing the location of each station reporting, it was possible to estimate the orbit of the satellite as it circled the Earth.

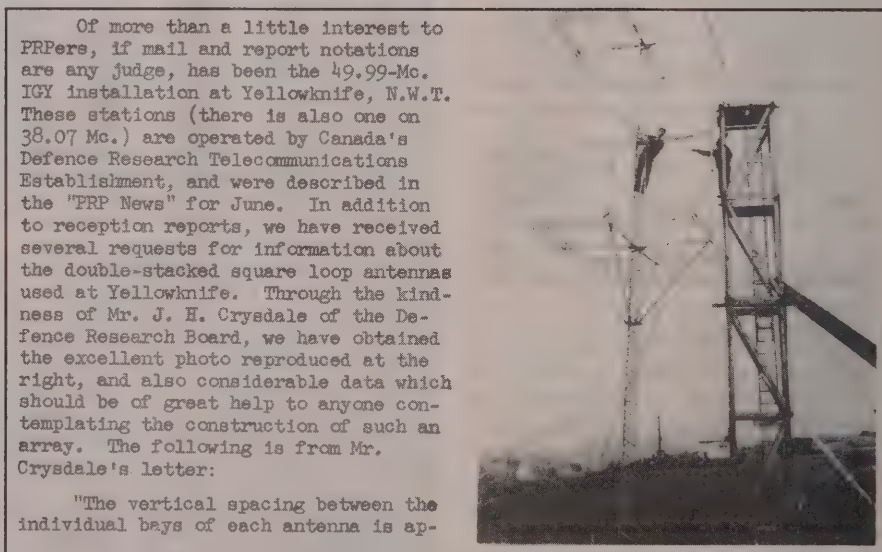
Dr. Kraus later reported that he could track Sputnik as it flew over his 96 helix

array in Ohio. At that time the WWV station was located near Washington, DC and transmitted time signals on 20 Mc. At night, when the signals generally faded, an occasional meteor would provide sufficient ionization to reflect the WWV signal for reception. Dr. Kraus theorized that Sputnik, in moving through the lower limits of the ionosphere, might cause ions to be bunched up in front of the satellite, thus providing sufficient reflectivity to bounce radio waves from WWV. When he checked his chart recorder, he found that the WWV signal had indeed appeared at the time Sputnik crossed the path of his OSU telescope.

While Sputnik allowed people around the world to witness the birth of the space age, many believed the ability to launch an Earth-orbiting satellite could lead to nuclear weapons dropped anywhere on Earth. Some people responded by building their own bomb shelters. Others, especially hams, responded by joining their local Civil Defense organization. In spite of these sobering effects, however, atomic testing proved something of an opportunity for wave theorists to learn more about radio propagation. It had been discovered that atmospheric tests created propagation effects similar to those experienced during solar flares, and since amateurs had long been bouncing signals off the aurora borealis, the ARRL requested radio amateurs to report any unusual radio communications that might be associated with nuclear testing. Photo 4 is the ARRL announcement that appeared in the November 1957 issue of *QST*.

While Sputnik was significant as the first satellite launched by man, it was Explorer I, launched by the U.S. in 1958, that provided what many consider the greatest scientific accomplishment of the IGY: the discovery of areas of high-energy particles trapped within the Earth's magnetic field and largely responsible for the aurora borealis. The Van Allen Radiation Belts, named in honor of the University of Iowa professor credited with their discovery, were of importance to the VHF operator because of their DX potential. In the years prior to meteor scatter, it was "aurora work" that opened the door to DX on 2 meters. The so-called "buzz sessions," a name that describes the effect of auroral activity on

Photo 5. Dr. William H. Pickering, Dr. James A. Van Allen, and Dr. Wernher von Braun (left to right) hoist a model of Explorer I and the final stage after the launching on January 31, 1958. Explorer I, the first U.S. earth satellite, was launched by a Jupiter-C with U.S. Earth–IGY scientific experiments of Dr. James A. Van Allen, which discovered the radiation belt around the Earth. (NASA photo)



Of more than a little interest to PRPers, if mail and report notations are any judge, has been the 49.99-Mc. IGY installation at Yellowknife, N.W.T. These stations (there is also one on 38.07 Mc.) are operated by Canada's Defence Research Telecommunications Establishment, and were described in the "PRP News" for June. In addition to reception reports, we have received several requests for information about the double-stacked square loop antennas used at Yellowknife. Through the kindness of Mr. J. H. Crysdale of the Defence Research Board, we have obtained the excellent photo reproduced at the right, and also considerable data which should be of great help to anyone contemplating the construction of such an array. The following is from Mr. Crysdale's letter:

"The vertical spacing between the individual bays of each antenna is ap-

Photo 6. From the "PRP News," this is a write-up of the Yellowknife transmitters.

received signals, added many states to the VHF enthusiast's states worked list. Photo 5 shows Dr. Van Allen (center) along with Dr. Werner Von Braun (right) and the same Dr. Pickering (left) mentioned earlier in this article.

When Sputnik finally returned to Earth, Dr. Kraus reported that he could track its descent using radio waves reflected off its ionized debris trails. The source of the radio waves was once again the WWV station near Washington, DC. From "PRP News" February 1958:

Sputnik Scatter

MS-type propagation was recently put to work for a purpose far removed from point-to-point communication. Our source is a news clipping sent us by Ed Collins of the *QST* Advertising Department. The place was Ohio State University. There, Prof. John D. Kraus, W8JK, came up with a radio reflection system for tracking Sputnik I. With this method, "radio signals, at a frequency of 20 Mc., from radio station WWV near Washington, were detected at the university after being reflected from the ionization columns produced by the satellites in speeding through the upper atmosphere." Results? It was revealed that Sputnik I broke up into no less than eight separate pieces; these then disappeared one or two at a time until nothing was left on January 11.

Important resources of the IGY were the VHF beacons. Some amateurs made their own beacons using old phonographs and coded disks that keyed their transmitters with pre-programmed messages. Some beacons were nothing more than existing transmitters, such as the VOA transmitters in Japan. Others, such as the Yellowknife transmitters in the Northwest Territory in Canada, were erected specifically for the IGY. Photo 6, from the "PRP News," is a write-up of the Yellowknife transmitters.

The success of KH6UK and W6NLZ crossing the Pacific on 2 meters inspired others to follow. In the spirit of the IGY, Walt Morrison, W2CXY, coordinated a 2-meter transatlantic attempt with amateurs in Holland. Although success eluded them, this is perhaps the only coordinated attempt made during the IGY. Here's what PRP had to say (from "PRP News" April 1958):

144-Mc. Transatlantic Tests

The information for this item came to us the long way 'round; PPR observer Walt Morrison, W2CXY, came up with the idea, sent it off to the Radio Society of Great Britain, and we read about it in the March 1958 RSGB Bulletin. Walt feels that neither meteor nor auroral propagation looks too good for accomplishing that dream of 2-meter operators, a transatlantic contact. He believes that three possibilities remain—ionospheric scatter under conditions of intense F2-layer ionization, moon bounce, or tropospheric propagation. Whatever the mode of propagation, then the signals, if there are at all, will be extremely weak. Obviously, an emulation of the W6NLZ-KH6UK effort is called for, making use of the best possible equipment.

W2CXY will operate on 14.095 Mc. and 144.01 Mc. simultaneously transmitting "IGY TEST IGY TEST IGY TEST DUAL 14095/144010 DE W2CXY" at about 20 wpm for five minutes commencing at 1330, 1900 and 0300 GMT (0830, 1400 and 2200 EST) on Saturdays and Sundays and at 2330 GME (1830 EST) Mondays to Fridays. The five-minute transmission period will alternate with similar listening periods on both bands.

Equipment to be used by W2CXY includes a Collins KWS-1K running 1 kw to a ground plane on 14 Mc. For 144 Mc., the transmitter comprises a modified SCR522 driving push-pull 4.125As also running 1 kw input and feeding a 40-element array consisting of four 16 ft long Yagis spaced 12 ft by 12 ft on a 70-ft tower. A new coaxial final using an Eimac 4CX1000A tunable from 60 to 450 Mc. will be completed soon. The station is east of Chatham, New Jersey. Best of luck Walt!

It should be noted that a successful transatlantic QSO on 2 meters has yet to be accomplished and the coveted Brendan Trophy still awaits those who are the first to succeed.

In June 1958 the following special bulletin went out to PRP observers via "PRP News." This is a perfect example of how amateur radio was uniquely suited to make special IGY observations with little advance notice.

Important Bulletin to all Satellite Listeners!

As some of you may have heard, something very puzzling has been noted in connection with the 20 and 40 Mc. transmissions from USSR satellites. This is the "ghost satellite" or antipodal reception effect. It seems that on many occasions reception has been possible not only when the Sputnik was within line of sight but when it was on the opposite side of the world!

To pick this up is quite simple. One listens for the signal at plus or minus about 52 minutes from the time it makes a close pass. The satellite will then be about half way around the world with respect to the observer. The signal seems to reappear for a period of three or four minutes and then vanishes until the satellite is once more within line of sight. The antipodal effect is heard best in

the evening hours, and is observable on about 50 percent of the days, on the average.

It is very difficult to explain this reception without more information on its characteristics and properties. Ham reports can be absolutely invaluable here. The data required are (1) whether the signal was heard or not, and if so, roughly how strong it was; (2) at what times the operator listened and (3) the direction from which the signal was coming, if this can be determined or estimated. Note that, as in PRP reporting, negative reports are fully as important as positive ones. Note also that correct signal identification is vital; here the "L" signal now being transmitted is very useful.

Please try your hand at making these observations and send your results to PRP Headquarters at 530 Silas Deane Highway, Wethersfield, Connecticut, USA. We'll see that they go to the people who can figure this thing out. Thank you.

P.S. *Please* keep all satellite reports *separate* from your regular VHF propagation reports!

2-METER STANDINGS

Figures are states, U. S. call areas, and mileage to most distant station worked.

W1REZ	29	8	1175
W1AZK	24	7	1205
W1RFU	22	7	1120
W1OAX	22	6	800
W1AJR	21	7	1130
W1HDQ	20	6	1020
W1MMN	20	6	900
W1IZY	19	6	875
W1AFO	17	6	920
W1ZJQ	17	6	860
W1CLH	17	5	450
K1ABR	16	6	810
W1BCN	16	5	650
W1KHL	16	5	570
W2CXY	37	8	1360
W2ORI	36	8	1250
W2NLY	35	8	1390
W2AZL	28	8	1050
K2GQI	27	8	1000
W2BLV	25	8	1020
K2IEJ	24	7	1060
W2DWJ	23	6	860
K2HOD	23	7	950
W2AMJ	22	6	960
W2SM	22	6	940
K2CEH	21	8	910
W2LWI	21	6	700
W2RXG	20	6	700
W2UTH	19	7	880
W2RGV	19	6	720
K2RLG	17	6	980
W3RUE	30	8	975
W3GKP	29	8	1020
W3KCA	28	8	1110
W3TDF	28	8	915
W3SGA	26	7	700
W3FPH	22	8	1000
W3NKM	20	7	730
W3LNA	20	7	720
W3LZD	20	7	650
W4HJQ	36	8	1150
W4HHK	35	9	1280
W4ZXI	34	8	950
W4AO	30	8	1120
W4MKJ	28	8	850
W4UMF	27	8	1110
W4VLA	26	8	1000
W4JCJ	23	6	725
W4EQM	22	8	900
W4WNH	22	8	800
W4OLK	20	6	720
K4EUS	19	6	710
W4CPZ	18	6	650
W4TLV	18	7	1000
W4RFR	18	7	820
W4MDA	17	6	650
K4YUN	16	8	830
W4CLY	15	5	720
W4RMU	10	5	860
W4LNG	10	5	800
W4KCQ	10	4	860
W4GIS	9	2	335
W5RCI	33	9	1215
W5DFU	25	9	1300
W5AJG	22	8	1280
W5JWL	21	7	1150
W5KTD	20	8	1250
W5LPG	19	6	1000
W5ML	15	5	700
W5PZ	14	6	1255
W5FSC	12	5	1390
W5HEZ	12	5	1250
W5CVW	11	5	1180
W5NDE	11	5	625
W5VY	10	3	1200
W5ONS	9	3	950
W5FEK	8	2	560
W6NLZ	12	4	2540
W6DNG	9	5	1040
W6AJF	6	3	800
W6ZL	5	3	1400
W6MMU	3	2	950
W7VMP	11	5	1280
W7JRG	6	3	1040
W7LHL	4	2	1050
W7JIP	4	2	900
W7JU	4	2	353
W8KAY	38	8	1020
W8WXV	35	8	1200
W8LOF	33	8	1060
W8PT	32	8	985
W8SVI	30	8	1080
W8SFG	30	8	1000
W8LPD	29	8	850
W8EHW	28	8	860
W8WRN	28	8	680
W8BAX	27	8	960
W8DX	26	8	720
W8ILC	25	8	800
W8JWV	25	8	940
W8NOH	21	8	975
W8LCY	21	7	610
W8BLN	21	7	610
W8BLN	18	7	780
W8GTK	18	7	550
W9KLR	39	9	1160
W9WOK	39	9	1150
W9GAB	32	9	1075
W9REM	31	8	850
W9AAG	30	8	1050
W9GIH	30	8	830
W9EQC	26	8	820
W9ZHL	25	8	700
W9BPV	25	7	1030
W9PBP	23	8	820
K9AQP	23	7	780
W9LF	22	7	825
W9KPS	22	7	690
W9PMN	19	6	800
W9ALU	18	7	800
W9JIY	17	8	790
W9LEE	16	6	780
W9DDG	16	6	700
W9DSP	15	6	720
WØSMJ	27	8	1075
WØIHD	27	7	890
WØBFB	27	8	1060
WØGUD	25	7	1065
WØRUF	23	7	900
WØINI	21	6	830
WØUOP	21	7	900
WØTGC	21	7	875
WØZJB	18	7	1180
WØRYG	17	6	925
WØIFS	16	6	1100
WØJHS	13	5	700
WØIC	12	5	1240
VE3DIR	28	8	1100
VE3AIB	26	8	910
VE3BQN	19	7	790
VE3AQG	17	7	800
VE3DER	16	7	820
VE2AOK	13	5	550
VE3BPB	14	6	715
VE7FJ	2	1	365
KH6UK	1	2	2540

Figure 3. An example of the QST *Standings box published periodically in "The World Above 50 Mc." column. Note the last entry of KH6UK.*

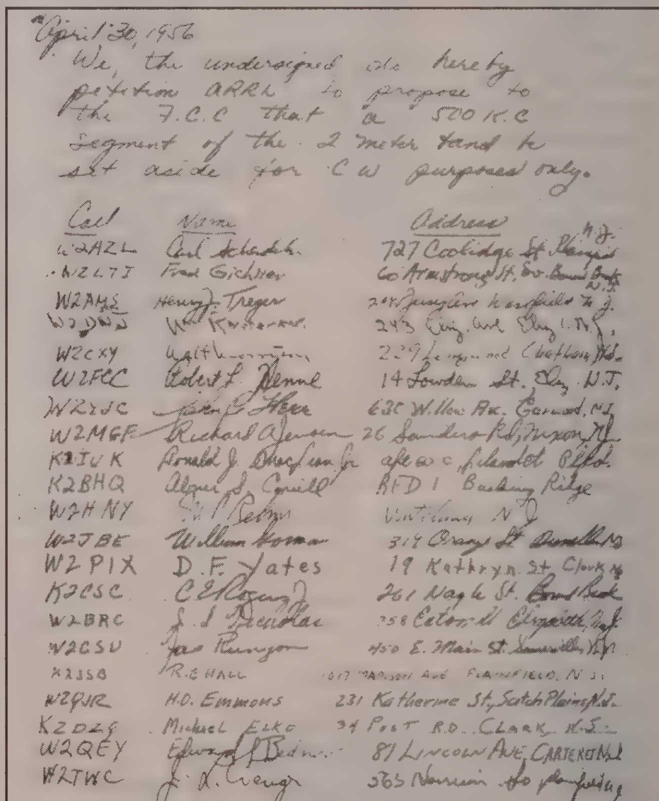
During the 1958 VHF contest Walt Morrison, W2CXY, took best DX working the *Perseids* meteor shower. Note that in spite of the impressive distances worked by many amateurs, including Walt, still nothing compared to that of Tommy and John's record-breaking QSO of 1957, as illustrated in the *QST* Standings box as shown in Figure 3.

With the popularity of wide-band crystal-controlled converters, and the ever-increasing number of high-powered VHF stations, crowding and cross modulation started to become problems. In 1956 W2CXY and others petitioned the FCC through the ARRL to reserve part of the 2-meter band for exclusive CW use for the purpose of "furthering the understanding of this medium about which so little is understood." The fact that the IGY was actually encouraging studies of the ionosphere at this time didn't hurt their cause. Figure 4 is a copy of an informal petition to the FCC for the CW subband.

This excerpt from "PRP News" of August 1958 shows that the FCC recognized the contribution of these hams:

FCC Proposes CW Segments for 50 and 144 Mc.

In response to a request from the ARRL, the FCC has issued a notice of proposed rule making seeking comments on the establishment of 100 kc. segments exclusively for CW at the low ends of the 50 and


April 30, 1956
We, the undersigned do hereby petition ARRL to propose to the F.C.C that a 500 K.C segment of the 2 meter band be set aside for CW purposes only.

Call | Name | Address
W2AZL
W2CXY
W2FCC | Robert L. | 14 ... St. ... N.J.
W2MGF | Richard ... | 26 ...
K2BHQ | | RFD 1 Basking Ridge
W2HNY
W2JBE | William ... | 314 Orange St ...
W2PIX | D.F. Yates | 19 Kathryn St Clark NJ
K2CSC | | 261 ...
W2BRC
W2CSU | | 450 E. Main St. ...
K2JSB | R.E. HALL | ... PLAINFIELD, N.J.
W2QJR | H.O. Emmons | 231 Katherine St, Scotch Plains N.J.
K2DZG | Michael Elko | 34 Post RD. CLARK N.J.
W2QEY | | 81 LINCOLN AVE, CARTERET N.J.
W2TWC

Figure 4. A copy of an informal petition to the FCC for the CW subband.

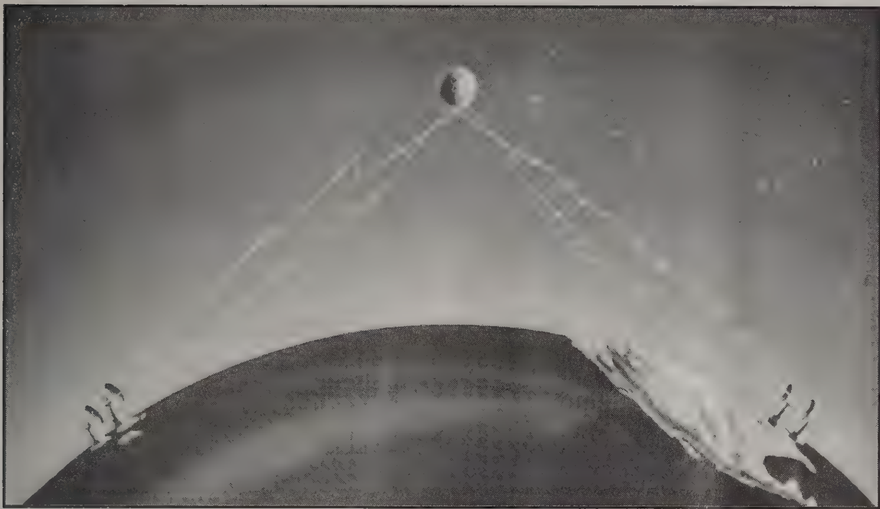


Photo 7. This is a graphic illustration of satellite communications from the book From Semaphore to Satellite, *by Anthony R. Michaelis, published by the International Telecommunication Union in 1965. (Photo courtesy of the ITU)*

144 Mc. bands. This is of special interest to PRPers because the League based much of its argument in favor of the proposal on contributions to the art made by amateur groups such as ours. The text of the League's proposal and the Commission's notice appear on pages 54–55 of August *QST*. Perhaps you will wish to express your own views on this matter directly to the FCC, Washington, DC by August 29th so that they may know the extent to which the League's proposal is supported by amateurs.

It is interesting to note that the FCC ultimately did reserve 100 kHz at the low end of 2 and 6 meters exclusively for CW, both of which exist today.

"Operation Smokepuff" was an IGY experiment using rockets launched from White Sands, New Mexico to release ionizing chemicals into the atmosphere. Radio amateurs were asked to bounce their radio signals off the ionization cloud and report any stations heard or worked. From "PRP News" August 1958:

Smokepuff Results

Observers interested in "Operation Smokepuff" (*QST*, May 1957) who have not been able to take part because of living too far from Alamagordo, New Mexico will be glad to hear that the latest group of firings has been declared a scientific success. The object of these tests, you'll recall, was to create a patch of ionization with chemicals released from a research rocket. A network of hams was organized to help prove the existence of this ionization by bouncing their HF and VHF signals from one side of the patch to the other.

On May 20, 21 and 22, Nike-Cajuns soared aloft with their ionizing cargoes. A "hardware" difficulty cause the middle missile to release its gas 30 km. higher than the intended 120 km. altitude but, other than this, things went well. On all three occasions, the released chemicals produced visible clouds larger in apparent diameter than the moon, making excellent photography possible. The first test produced a 15-minute echo on a 3-Mc. ionospheric recorder.

Throughout the IGY many amateurs experimented with moon-reflection work, or simply moonbounce. Although many hams reported hearing their own echoes, it wasn't until years later, 1960 in fact, that the first amateur QSO would take place. It was during the IGY, however, that the Navy began installation of a two-way moonbounce network that later became operational between Washington, DC and Hawaii, also in 1960. Photo 7 is from the book *From Semaphore to Satellite,* by Anthony R. Michaelis, published by the International Telecommunication Union (ITU) in 1965.

Although an amateur moonbounce QSO did not take place during the IGY, the seeds were planted for serious VHF amateurs to reach for this loftiest of goals—the ultimate DX record. The events leading up to the first successful amateur moonbounce will be covered in a future article.

As the IGY came to a close, special certificates were awarded to those who participated in the ARRL's Propagation

IGY
1957 1958
National Academy of Sciences
U. S. National Committee for IGY

Air Research and Development Command
United States Air Force
Air Force Cambridge Research Center
Geophysics Research
Directorate

The American Radio
Relay League, Incorporated
International Geophysical Year
Propagation Research
Project

ARE PLEASED to acknowledge the outstanding services rendered by WALTER J. MORRISON operating amateur radio station W2CXY during the period of the United States program of the

International Geophysical Year
JANUARY 1957 — DECEMBER 1958

Your unselfish cooperation with the ARRL-IGY Propagation Research Project has contributed significantly to the world's scientific knowledge in the field of v.h.f. ionospheric radio propagation.

Executive Director, U.S.N.C. IGY
President, A.R.R.L.

Photo 8. A copy of the certificate issued to Walt Morrison, W2CXY, for his participation in the ARRL's Propagation Research Project. (Author photo)

Research Project. Photo 8 is a copy of the certificate issued to Walt Morrison, W2CXY.

There is no doubt that amateur radio made significant contributions to the scientific purpose of the International Geophysical Year of 1957–1958. Although much has been said about this, Ed Tilton, W1HDQ, may have said it best when he wrote the following words on the 20th anniversary of his *QST* column "The World Above 50 Mc." in December 1959.

Amateur radio stock rose markedly in the world of science with the announcement of the success of KH6UK and W6NLZ in working from California to Hawaii on 144 Mc. in 1957 and on 220 Mc. in 1959. Our contribution to the world-wide effort in the International Geophysical Year has brought and is bringing words of appreciation from people in many high places. . . . If, in 1979, we can say that the occupants of the world above 50 Mc. have done as well in the second 20 years as they have in the first 20 of this department's existence, the cause of amateur radio as a whole will have been well served."

What Did the IGY Mean to Me?

Compiled by Joe Lynch, N6CL

In commemoration of the 50th anniversary of the start of the International Geophysical Year (IGY), I asked for responses to the question: What did the IGY mean to me? Here are a few of the responses that I have received so far:

Joe Taylor, K1JT:

In 1957 I was 16 years old and a sophomore in high school. My two-years-older brother Hal and I had passed our Amateur Extra Class license examinations a year or so earlier—I was K2ITP, and he K2ITQ—and together we had built a very capable 6-meter station, mostly from free or almost-free military surplus equipment and junked TV sets. We were keenly interested in all things technical, and especially VHF radio communication. We subscribed to *CQ* and *QST* and avidly devoured all the technical articles that arrived each month.

When the ARRL IGY Propagation Research Project came along, we eagerly signed up as volunteer observers. As I remember it half a century later, our main task was to get on the air, listen, and file biweekly reports on any unusual propagation observed. This was easy to do, because (except for filing the reports) it was exactly what we had been doing anyway! Of course, we understood that we were entering the peak years of solar cycle 19, and our favorite band, 50 MHz, was already exhibiting some exciting propagation. We were "riding the MUF," looking for thrills. Many were the mornings that we pointed our beam northeast and listened to the video carrier of BBC channel 2 at 51.75 MHz, 30 dB over S9, and wished that European operators had privileges on our band. We did make many exciting DX QSOs, despite the licensing restrictions. One that I recall vividly was one of the first US-Argentina 50 MHz contacts ever, with LU9MA, I think in the fall of 1956.

We dutifully filed our reports on aurora, *F2*, *E*-skip, and the like, every few weeks for a year or more. We proudly displayed the "Consistent Reporting Award" sent to us by the ARRL, with its accumulating endorsement stickers. This was our first taste of doing systematic research in a scientific field, and although our parts in it were small, we liked it. Obviously the experience had positive effects on both Hal and me, and helped to shape our career interests. We both studied physics in college, went on to complete Ph.D. degrees, and both became professors of physics. Hal died of cancer in 2002, or he too would be writing here about what the IGY meant to him.

Bill Tynan, W3XO:

The IGY gave hams, particularly those interested in VHF ionospheric propagation, a chance to participate in an important scientific investigation. When I was in college back in the late 1940s, I considered solar physics as a career, but concluded that everything about the Sun was already known. Was I ever wrong!

Al Katz, K2UYH:

I was licensed in '56, in high school and just getting started on VHF. I remember being impressed with the articles on the upcoming IGY year in *QST* and *CQ* magazines. But when 1957 arrived, I do not remember it having a great impact on my involvement in ham radio. I was not much of a 6 meter operator; I did make my first 2 meter aurora QSOs about this time. And study of the aurora borealis was part of the IGY. Sam Harris, W1FZJ, then VHF editor of *CQ*, was stirring my interest in VHF and EME. Sam and the IGY year certainly were a factor in steering many young hams toward careers in science and engineering. In the US, we need something similar today.

Arnie Coro, CO2KK:

The International Geophysical Year, 1957, a very well-organized scientific effort that was aimed at studying, among other things, the activity of the Sun during the maximum of Cycle 19 (so far, as you know the most powerful cycle that we have registered), did have a tremendous and unexpected impact in my life. I was 15 years old and already had an "Amateur Radio Operators Certificate" but not an actual license with a callsign. So I used to visit the local radio amateurs and operate their stations as a "second operator," something that was allowed at that time.

Then on the 4th of October of 1957, something really fantastic happened. The Soviet Union announced the launching of Sputnik I, the first manmade object to orbit the Earth by reaching the 4 kilometers per second required speed to keep it circling the Earth.

The AP and UP news agencies announced two frequencies, one very near WWV's 20,000 kHz channel and the other one around 40,000 kHz. Using my Super Pro 400 receiver and a 40 meter band half-wave dipole, I was able to pick up the 20,000 kHz signal around 20,003 to 20,005, although the calibration of their radio did not allow me to know the exact frequency. But the BIP ... BIP ...BIP ... of Sputnik I was there, coming out of the loudspeaker. I then went to see Oscar Morales Tur, CO2OM (Oscar, CO2OJ's dad), and we talked about the Russian satellite. Oscar Sr. was also able to pick up the signals and we even taped them on a Webcor tape recorder using quarter-inch tape. I then contacted a friend of my grandfather who was a newspaper reporter, and told him we had picked up the signals, explaining that not one but three Cuban radio amateurs had heard several passes of the satellite, because later we learned that Miguel J. Enciso, CO2CT, had also heard Sputnik I. Both Oscar Sr. and Miguel are now SK, and I will always remember them for all what they taught me about amateur radio.

The next thing that happened was that my report was published in one of Havana's most important newspapers, *Informacion,* and later Alberto Giro, CO2GY, who was a columnist for the *Diario de la Marina,* another of the capital's newspaper, also published a report.

So, as you may realize, the IGY was very important for my amateur and also professional radio careers, as from then on it was simply impossible to stay away from the radios at any spare time I had from the senior high school that I was attending at that time!

P.S.: For the skeptics who questioned if we had heard or not heard Sputnik I, we kept the tape recording available, and Oscar Sr. made a copy and gave it to the CMQ Radio News Department which played it on the air on one of the newscasts. A year later, using a modified FM tuner, we also picked up Explorer I, which used a frequency slightly above the 108 MHz top end of the FM broadcast band, and as it happened with the first ever EME contact from Cuba between CO2KK, Arnie Coro, and KB8RQ, Gary Crabtree.

I was also involved in the first attempts to communicate via satellite with my amateur radio station. But that event passed by without me taking down notes, so now I don't remember which satellite was used or when it happened!

Quarterly Calendar

The following is a list of important dates for EME enthusiasts.

Nov. 1, 2007	Last Quarter Moon
Nov. 4, 2007	Good EME conditions
Nov. 9, 2007	New Moon and Moon Apogee
Nov. 11, 2007	Very poor EME conditions
Nov. 17, 2007	First Quarter Moon and *Leonids* Meteor Shower Peak
Nov. 18, 2007	Moderate EME conditions
Nov. 24, 2007	Full Moon and Moon Perigee
Nov. 25, 2007	Moderate EME conditions
Dec. 1, 2007	Last Quarter Moon
Dec. 2, 2007	Moderate EME conditions
Dec. 6, 2007	Moon Apogee
Dec. 9, 2007	New Moon. Very poor EME conditions
Dec. 13, 2007	*Geminids* Meteor Shower Peak
Dec. 16, 2007	Good EME conditions
Dec. 17, 2007	First Quarter Moon
Dec. 22, 2007	Moon Perigee and Winter Solstice
Dec. 23, 2007	Moderate EME conditions; *Ursids* meteor shower peak
Dec. 24, 2007	Full Moon
Dec. 30, 2007	Moderate EME conditions
Dec. 31, 2007	Last Quarter Moon
Jan. 3, 2008	Moon Apogee
Jan. 4, 2008	*Quadrantids* meteor shower peak
Jan. 6, 2008	Very poor EME conditions.
Jan. 8, 2008	New Moon.
Jan. 13, 2008	Good EME conditions.
Jan. 15, 2008	First Quarter Moon.
Jan. 19, 2008	Moon Perigee.
Jan. 20, 2008	Poor EME conditions.
Jan. 22, 2008	Full Moon
Jan. 27, 2008	Moderate EME conditions
Jan. 30, 2008	Last Quarter Moon
Jan. 31, 2008	Moon Apogee
Feb. 3, 2008	Very poor EME conditions
Feb. 7, 2008	New Moon and annular Solar Eclipse that will only be visible over some parts of Antarctica. A partial eclipse will be visible throughout New Zealand and some parts of eastern Australia.
Feb. 10, 2008	Good EME conditions
Feb. 14, 2008	First Quarter Moon and Moon Perigee
Feb. 17, 2008	Moderate EME conditions
Feb. 21, 2008	Full Moon and Total Lunar Eclipse visible throughout most of the Americas, Africa, and Europe
Feb. 24, 2008	Moderate EME conditions
Feb. 28, 2008	Moon Apogee
Feb. 29, 2008	Last Quarter Moon

—EME conditions courtesy W5LUU.

Current Contests

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 24-25.

January: The ARRL VHF Sweepstakes is scheduled for the weekend of January 19-20.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or the URL: <http://www.arrl.org>.

Current Meteor Showers

November: The *Leonids* is predicted to peak at around 0250 UTC on November 18.

December: Two showers occur this month. The first, the *Geminids,* is predicted to peak at around 1645 UTC on December 14. The actual peak can occur 2.5 hours before or after the predicted peak. It has a broad peak and is a good north-south shower, producing an average of 100–120 meteors per hour at its peak.

The second, the *Ursids,* is predicted to peak on December 23. It is an east-west shower, producing an average of no greater than 10 meteors per hour, with the rare possibility of upwards of 90 meteors at its peak.

January: The *Quandrantids,* or *Quads,* is a brief but very active meteor shower. The expected peak is around 0640 UTC on 4 January. The actual peak can occur three hours before or after the predicted peak. The best paths are north-south. Long-duration meteors can be expected about one hour after the predicted peak.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's "VHF Propagation" column starting on page 80. Also visit the International Meteor Organization's website: <http://www.imo.net>.

Pounding the Key on 6 Meters
A Summer of 6-meter CW Fun

Does operating CW give one an advantage? Features Editor WB2AMU decided to conduct his own informal test of that theory. Here are the results of his efforts.

By Ken Neubeck,* WB2AMU

In an article that I wrote for the Spring 2007 issue of *CQ VHF* ("CW—An Important Mode on VHF"), I discussed in detail the advantages of operating CW on the VHF bands and why it would continue to be an important mode in the future. I pointed out, among other things, the ability of CW to punch through marginal conditions and its usefulness in working DX on 6 meters. The article focused on the positive merits of CW and the fact that many operators would still use it on the VHF bands even though it was no longer an FCC requirement for an amateur radio license.

With this in mind, I thought that I would conduct my own informal survey by concentrating more on using CW rather than SSB on the VHF bands during the summer of 2007. All too often in the past, it seemed easy to run a string of SSB QSOs on 6 meters when the band was open. This past summer I decided I would specifically work on calling CQ more on CW during some of the better 6-meter sporadic-*E* openings and see which stations would respond. As a rule, in the past I usually did not call CQ often, except during intense openings. I did this primarily because I was still resolving both antenna and interference issues at my home QTH on Long Island, New York.

However, with recent improvements in my TV and other appliance setups, I am now able to run a moderate amount of power (150 watts) to a two-element Yagi on 6 meters without causing significant interference. Previously, I could only run 10 watts at home, as higher power levels would get me into the phone and the front end of the TV set. By now being able to put out a decent signal for the most part, I could actually call more CQs and expect to get answers to my calls.

Thus, during the summer I entered into a campaign of a significant amount of calling CQ during good 6-meter sporadic-*E* openings and found some interesting results that not only show the value of CW, but also the value of calling CQ at the right times.

*CQ VHF Contributing Editor, 1 Valley Road, Patchogue, NY 11772
e-mail: <wb2amu@cq-vhf.com>

Photo A. Here is the simple two-element homemade Yagi used on 6 meters at WB2AMU's QTH. The antenna consists of a two-inch thick closet pole that has 1/4-inch rod material inserted into it for the elements. (Photos by the author unless otherwise noted)

The Setup at My QTH

My home setup includes a classic Kenwood TS-670 transceiver that puts out 10 watts on 6 meters. I hook this up to a Mirage A1015G amplifier that puts out roughly 150 watts, and this goes to a homemade two-element Yagi that is up about 25 feet (Photo A). This is a modest

setup on 6 meters that is limited because of the size of my lot on Long Island. There are many strong signals on 6 meters that come from great stations that have bigger antenna arrays and higher power amplifiers. However, a large number of 6-meter operators have moderate setups, usually running a maximum of 100 watts from an HF-plus-VHF transceiver with a multitude of different antennas ranging from 40-meter dipoles to seven-element 6-meter Yagis. However, if we consider a moderate setup such as mine as an average station, the results that were obtained should be reasonably achievable by similar or better stations.

I use a straight key when I am on CW, as I have always preferred that for my ham radio operations. The key that I have been using with my base station at home for about the last ten years is a vintage brass key that is about 80 years old (Photo B); I found it in an antique store and bought it for $15. I have it mounted on a nice piece of wood and it has the best spring action out of all the straight keys I have used. After the article I wrote for the Spring issue of *CQ VHF*, I received an e-mail from another straight-key operator, Karl Zuk, N2ZK, who got on 6 meters for the first time this past summer. Photo C shows his collection of straight keys, so it looks like there are more straight-key operators out there than one would think.

As I live on a geographically challenged one-third acre lot, I had to find the right antenna setup for 6 meters that would fit in the backyard and not be too noticeable. I ended up with a very simple setup consisting of a homemade two-element Yagi that uses a closet pole for the mast of the beam and 1/4-inch rod material inserted into the mast. I have it mounted on 25 feet of aluminum mast material that I had bought over the years from RadioShack. At this point, I have not bothered to put a rotator on the setup, as I generally point it west or southwest (remember that I live on eastern Long Island and I do not have that many openings to the east of me!)

CQ Sporadic-*E*!

There were at least five or six good U.S. sporadic-*E* openings during which I was able to do well by using one beam heading, choosing one frequency, and holding it while calling CQ. As many VHF operators know, sporadic-*E* openings on 6 meters can range from weak affairs to very strong conditions.

Photo B. This is the straight key used by the author at his home station, along with some of the QSLs that came in the mail during the summer. The key is an old brass key that goes back about 80 years, and it is mounted on a varnished piece of wood.

One major advantage of being able to hold a frequency on 6 meters and call CQ is that eventually some of the weaker sounding stations that usually come in via double-hop sporadic-*E* will call. A case in point is a good sporadic-*E* opening that I experienced on the evening of June 30th. Beginning at 7:30 PM local time, I was working several stations in the Midwest in 9-land and 8-land in the CW portion of the band, when I worked KØCL in Colorado. I then found a clear spot a few minutes later on 50.095 MHz and started calling CQ. I was able to hold the

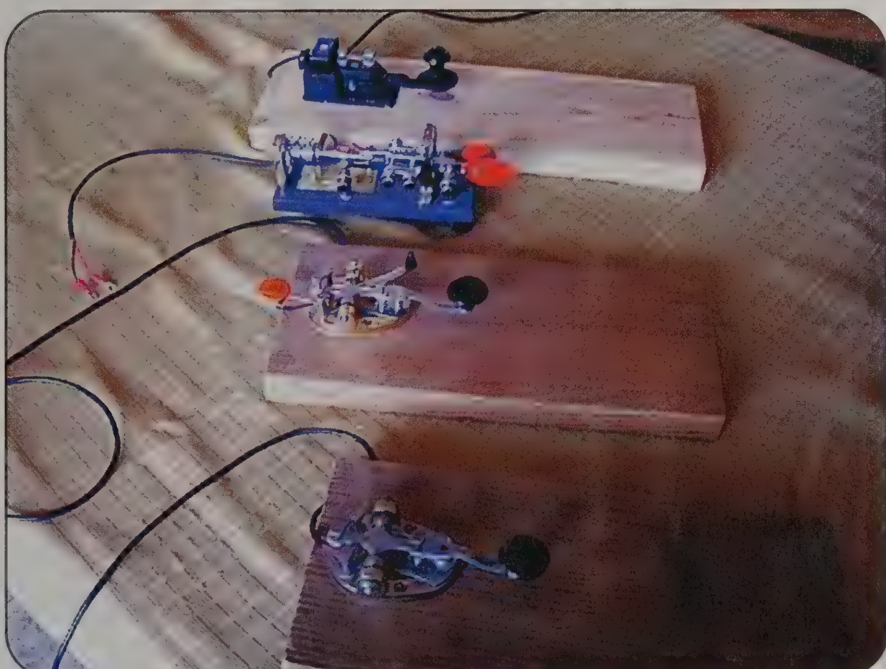


Photo C. Here is a selection of straight keys that Karl Zuk, N2KZ, uses at different times for his work on HF and 6 meters. (Photo by N2KZ)

Photo D. A two-element Yagi that WB2AMU made for portable operation. It is designed to be mounted in a telescoping tripod, and because of its light weight, it can be positioned on the car roof while parked.

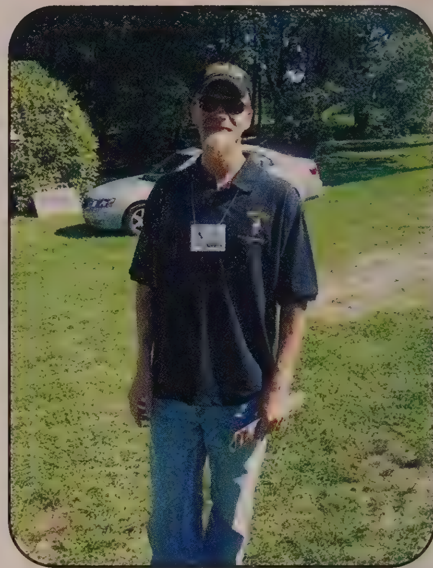


Photo E. Tim Havens, NN4DX, is the force behind one of the most active 6-meter spotting sites, dxers.info. This site proved to be a most valuable tool in spotting some of the rare grids and DX stations on 6 meters during the summer of 2007.

frequency and had stations in the Midwest coming back to my CQ, when I started hearing weaker signals come back to me, indicating double-hop activity! I proceeded to work W5ZF in New Mexico, WØETT in Colorado, N7KO in Arizona, N5KY in New Mexico, W6OUU in Idaho, and W6PJ in Arizona, all over a 12-minute period. These stations were interspersed with a few Midwest stations, too, so my CQing was bringing them out. I would venture to say that more stations are now listening on 6 meters, so it paid off to call CQ at the right time to draw them out. Some of the signals were marginal, so it is doubtful that I would have been able to work them on SSB instead of CW.

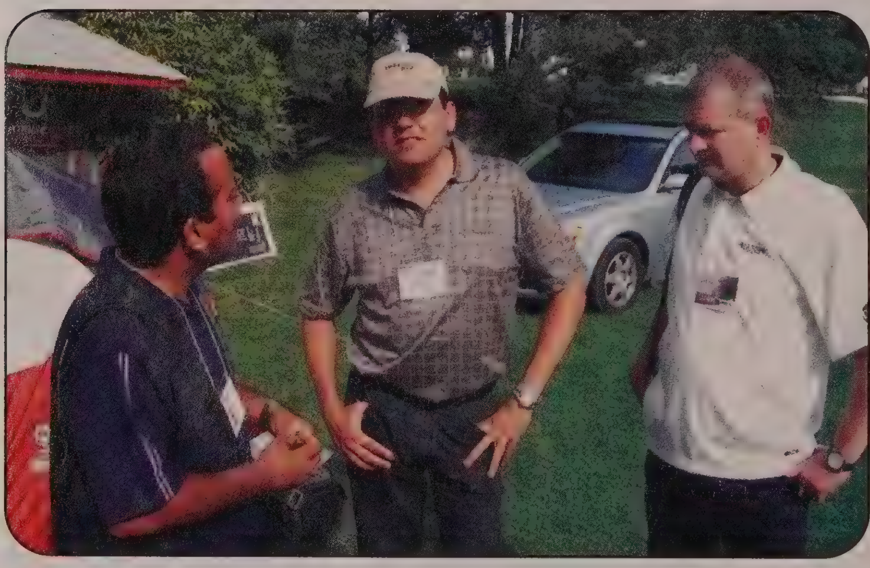


Photo F. These three DX stations, seen here at SMOGfest 2006, keep their countries active on the Magic Band every summer. They are Ted, HI3TEJ, Jose, EA7KW, and Johan, ON4IQ. All three are good CW operators who can pull in weak signals during marginal openings.

I had similar good fortune over the month of July on days when the sporadic-*E* skip was strong. Sometimes the skip was only an hour or so long, as was the case for the CQ WW VHF Contest on the weekend of July 21st and 22nd. At about 6:45 PM local time, sporadic-*E* started to come in full force after several hours of very weak band conditions. After working a few stations in 8-land and 4-land, I found an opening on 50.093 MHz in the CW band and started to call CQ. For about 25 minutes I was almost able to keep a rate of one contact a minute, and I worked into the Ohio, Michigan, and Illinois areas. At some point, there were no answers to my CQ, so I started to search around on SSB and pick up a few more contacts before the skip gave out.

During the summer of 2007, there was a fair amount of activity between the eastern U.S. and Europe, but it was not like it had been in 2006. I was able to cross the Atlantic two or three times, with one of my CW QSOs being with Gary, CU2JT, using a portable two-element beam setup mounted on my car at work at noontime on June 18th (Photo D). Some New England stations had posted the information on Tim Haven's site, dxers.info (Photo E). In addition to Gary, the regular European 6-meter group—

VHF Propagation Hunter Progress Report
The ARRL September VHF QSO Party

SEPTEMBER 2007 ARRL VHF CONTEST

Grids worked on 432 MHz

by WB2AMU in FN30, Long Island, NY

(Grids in green = typical line of sight, in yellow = tropo enhancement)

FN03	FN13	FN23	FN33	**FN43**	FN 53
FN02	FN12	FN22	**FN32**	FN42	FN 52
FN01	FN11	**FN21**	**FN31**	**FN41**	FN51
FN00	**FN10**	**FN20**	**FN30**	FN40	FN50
FM09	**FM19**	**FM29**			
FM08	FM18	FM28			
FM07	**FM17**	FM27			
FM06	FM16	FM26			

As mentioned in my article "VHF Propagation Hunter" in the Summer 2007 issue, I promised to try to provide periodic updates on some good tropo openings occurring on the VHF bands.

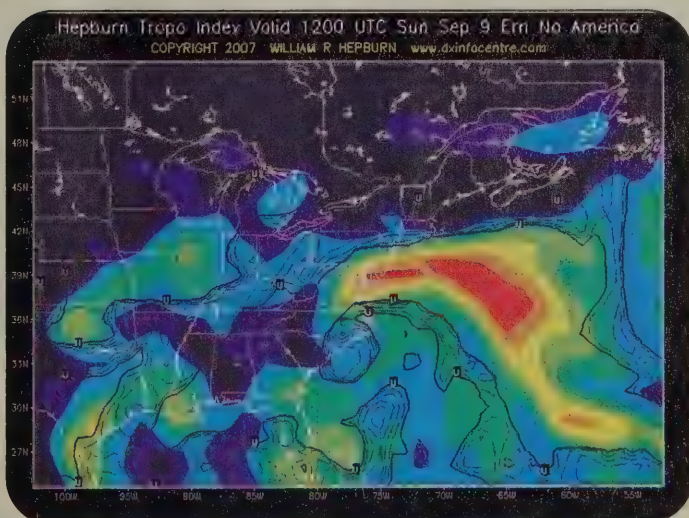
The ARRL September VHF QSO Party fell on a weekend when a tropical storm was moving towards the east coast of the United States. There was a predicted tropo opening based on the maps from the William Hepburn website for Sunday of the weekend (September 9th). At the hilltop location on Long Island (grid square FN30) where I operated QRP portable, I saw only modest tropo activity on the VHF bands on Saturday afternoon. However, when I arrived at the site early in the morning on Sunday, I saw some major tropo activity on all of the VHF bands.

When I first listened on 2 meters at 6:15 AM local time, I heard W4VHH in EM95 contacting N2RRA in FN31, and I knew that this was most likely a long tropo path. I was not able to get W4VHH, but then some signals started coming in very strong both on 2 meters and 432 MHz. Booming signals were coming from stations such as K3TUF (FN10), W4IY (FM19), KA3EJJ (FM19), KC3RE/rover (FM08), K8EP (FM09), K8GP (FM08), N3OC (FM19), and W3SO (FN00). After I worked KO4YC in FM17 on 2 meters at 8 AM, I asked him to move to 432 MHz and I was eventually able to work him there, too. I could not believe how loud some of the signals were on 432 MHz! The figure shows the grids that I worked on 432 MHz which appeared to be tropo-enhanced. Also look at the Hepburn tropo map and see how closely the two maps line up.

It was very fortunate that a significant tropo opening occurred during a high-activity event on the VHF bands such as the ARRL VHF QSO Party. I'll continue to update tropo-opening reports in the future as events occur.

This is the simple antenna setup that WB2AMU used during the September ARRL VHF QSO Party— a three-element 2-meter Yagi mounted on a telescoping tripod placed on the roof of his car. The 2-meter antenna was also able to load up on 432 MHz, where the pattern is similar to a dipole, and a couple of dozen stations were worked on this band as well.

This is the tropo map prediction for September 8th that appeared on William R. Hepburn's website, >http://www.dxinfocentre.com/tropo.html>. Note that the storm activity was in the North Carolina area and that fronts developed from the lower part of New York into western Pennsylvania, Maryland, and Virginia. (Map courtesy of the website of William R. Hepburn)



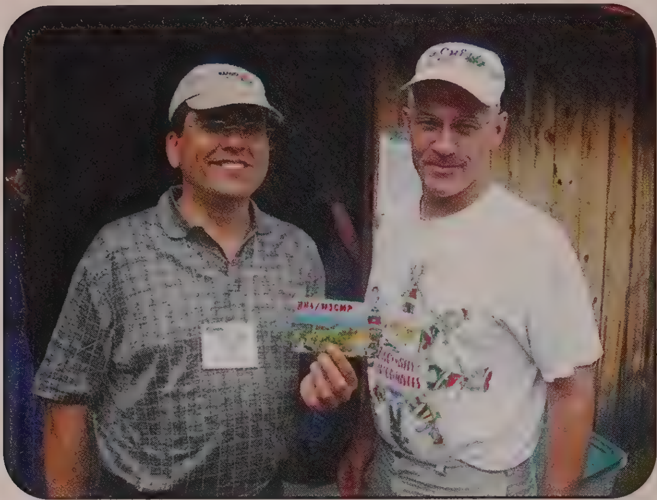


Photo G. Jose, EA7KW, is receiving a Haiti QSL for 6 meters from Chris, W3CMP, from his 2006 trip there. Chris repeated the same trip in June 2006 and worked many stations who needed this rare country on 6 meters.

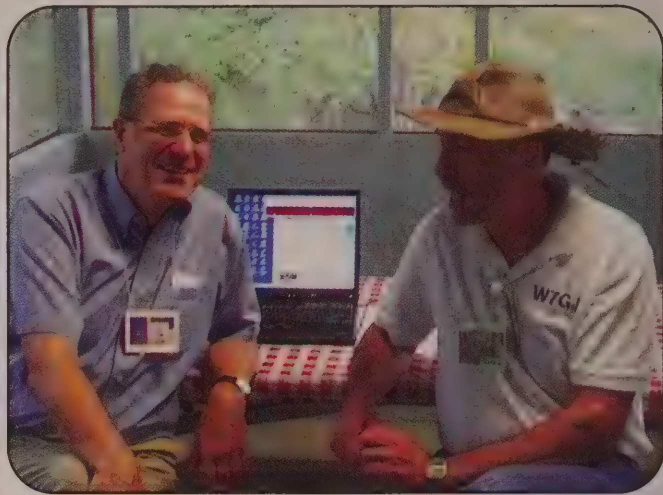


Photo I. Lance, W7GJ, on the right, with Joe Taylor, K1JT, the inventor of WSJT software. Several times during the past three summers, Lance generated some major pile-ups on 6 meters via double-hop sporadic-E.

including Johan, ON4IQ, Jose, EA7KW, and Joe, CT1HZE (Photos F and G)—were worked by several U.S. stations during a few transatlantic openings.

There were a number of Caribbean DX stations, including expeditions that were planned by veteran 6-meter operators such as Chris, W3CMP, in Haiti; Dennis, K7BV, in Belize; Jimmy, W6JKV, in Grenada; and Howard, WB4WXE, operating from Antigua as V26HS for over two weeks (Photo H). A lot of credit has to be given to these operators, as they kept listening and calling for several hours at a time. Belize, for example, is a location where there is only an occasional two-hop sporadic-*E* path to the East Coast. On July 13th I was lucky to finally work this one as a new country, with both V36M and V31UM being worked in a matter of ten minutes!

Cross-mode contacts using CW were very important for me, not only during my QRP efforts during the June VHF Contest, but also during situations where there were large pile-ups on stations in rare grid squares or rare countries. As I did in 2006, I was able to work Lance,

Photo H. Here is the view of the ocean and the three-element 6-meter Yagi at V26HS. Howard, WB4WXE, repeated his trip to Antigua in 2007 (he was there in 2006 as well) and stayed for a two-week period in June. He worked over 1600 stations on 6 meters as V26HE. Of those 1600 QSOs, 450 of them were with Europe. Howard concentrated on SSB, but he copied a number of CW stations for cross-mode contacts when conditions were not optimal. (Photo by WB4WXE)

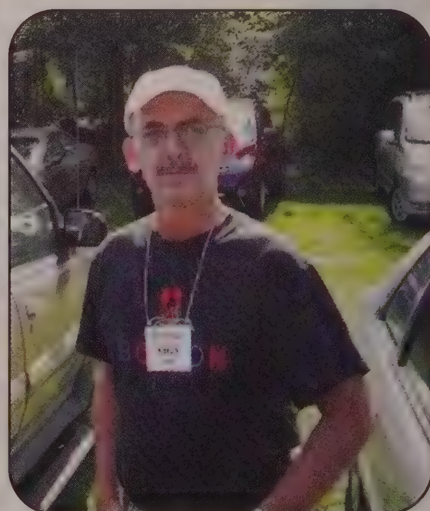


Photo J. Pete, VE3IKV, is an active mobile operator on 6 meters and also goes to rare grids in northern parts of Canada. In June 2007 he activated Nunavut as VFØX and made several CW QSOs in addition to SSB QSOs with the U.S. and Europe.

W7GJ, in Montana by calling him on CW in order to break the pile-up (Photo I). Lance specializes in EME work, where CW is important, and he, along with the other operators who have been mentioned in this article, are very good CW ops who can pick out a CW signal in the throng of SSB signals.

It was a good summer for me in that I picked up two new countries on 6 meters (Antigua and Belize), along with about ten new grids in the U.S., mostly in the western states, such as New Mexico and Colorado. CW was a major plus for me in getting some of these stations on 6.

Summary

On 6 meters during the summer there will be a number of times when conditions are optimal and when sporadic-*E* enhanced signals are booming. Sometimes these openings may last for only an hour or sometimes they last for a few hours. While it has been said that it is important to make noise on 6 meters when the band is quiet, the same can be said when the band is very active. That is because there may be more than one sporadic-*E* cloud formation, which can often lead to marginal or moderate double-hop sporadic-*E* conditions. Thus, during the very quiet times and during the very active times, it make sense to find an open frequency and call CQ.

More important, it can be seen that CW still remains a very important mode of operation. The great majority of the callsigns that I worked during this past summer appeared to be callsigns of hams who have been around a while. They certainly were proficient on CW. I worked a few newcomers, too, basing that judgment on the code speed or the newer callsign.

Newcomers to CW will find it most beneficial to learn this mode at least on a rudimentary level so that they are able to identify beacon messages on 6 meters. A good way to start is to learn the dits and dahs sequence for the numbers, as all beacons make use of numerical characters in their messages. For example, the K2ZD beacon in New Jersey sends the callsign, along with the grid FN20. Therefore, learning to be able to identify the numbers, such as "20"in this case, is a start for identifying potential sporadic-*E* skip conditions when certain beacons start coming in. While you may never want to use CW as your main mode of operation, it would be a major advantage to be able to copy the beacons and know where to point your antennas.

Moondata Update 2008 and Related Comments

One of the most important factors in EME communications is knowing when it is best to communicate via moonbounce. W5LUU presents a summary and table of the best and worst conditions for EME in 2008.

By Derwin King,* W5LUU

The Earth-Moon distance and the cosmic (sky) noise temperatures in the direction of the Moon are predictable, cyclical variables that set the basic quality of Earth-Moon-Earth (EME) communications for frequencies below 1.0 GHz. The best conditions occur when: (1) the Range Factor (Earth-Moon distance) is at the absolute minimum, and (2) the Sky Temperature toward the Moon, as seen from Earth, is the coldest along the moon path. While the Range Factor is independent of frequency, Sky Temperature decreases with frequency, up to ~1 GHz, and then levels out. The EME signal-to-noise ratio, in dB, is usually degraded from the ideal by a factor (DGRD, see below) which varies with time over hourly, daily, weekly, monthly, and yearly periods. The DGRD, in dB, for 144 and 432 MHz, and other pertinent EME data, are listed in the W5LUU Weekend Moon Data for each Sunday at 0000 UT and provide a guide for the basic EME weekend conditions (see the accompanying table). Random variables such as ionospheric disturbances, local noise, and polarization mismatch will increase the "apparent" DGRD.

EME conditions generally will improve in 2008, with all moon perigees at north declinations, but on many weekends the moon is at right ascension, where Sky Noise is 1 to 4 dB above minimum, and five good weekends are negated by New Moon. Many weekdays will be good or better. Over the next one to two years, as perigees occurs near the best cold sky region, conditions will improve. During the annual ARRL EME Contest period there are no ideal, high declination weekends for VHF due to the high sky temperatures. Dates will have to be a compromise. For 1296 MHz and up, several high declination dates are near perigee and near ideal.

Definitions

DEC (deg): Moon declination in degrees north and south (–) of the equator. This is cyclical with an average period of 27.212221 days. The maximum declination during a monthly cycle, plus and minus, ranges from 18.15 up to 28.72 degrees with a period (maximum to minimum and back to maximum) in about 19 years. *The last maximum was on 09/15/2006.*

RA (hrs): Right Ascension, in hours, gives the east-west position of the moon against the sky background. The average period of RA cycle is 27.321662 days, but it can vary by a day or so due to effects of the Sun on the Earth and Moon motion.

144 MHz Temp (K): The 144-MHz cosmic (sky) noise in direction of moon expressed as absolute temperature.

Range Factor (dBr): The additional EME path loss, in dB, due to Earth-Moon separation distance being greater than absolute minimum (348,030 km surface-to-surface). Varies from a low of 0 to 0.7 dB at perigee up to 2.33 $\pm$0.1 dB at apogee.

DGRD (dB): The degradation in EME signal-to-noise (in dB) due to: (1) the excess sky noise temperature (in dB) at the stated position of the Moon compared to the lowest cold sky temperature and the system noise temperature (all at the frequency of interest); plus (2) the Earth-Moon range factor (dBr) for the listed time and date. The tabulated DGRD is referenced to the lowest possible sky noise temperature along the Moon path, for a system noise temperature of 80 °K at 144 and 60 °K at 432, an antenna beam width of ~15°, and to the absolute minimum Earth-Moon (surface-to-surface) distance.

The dBr affects DGRD equally at all frequencies, but sky noise decreases rapidly as frequency increases. During a monthly lunar cycle DGRD can vary by 13 dB on 144 MHz and 8 dB on 432 MHz. DGRD varies less with small antennas than with large ones.

Moon Phase: Shows new moon (NM) and full moon (FM) along with the number of days (d) or hours (h) before (–) or after (+) these events. At NM sun noise is a problem, while at FM the EME conditions (at night) usually are more stable.

Conditions: Summary of EME conditions as controlled by DGRD at 144 MHz and NM. Conditions may be worse, due to ionospheric disturbance, local noise, and polarity, but not better than indicated. In general, 144 MHz DGRD <1.0 dB is considered Excellent, 1.0 to 1.5 is Very Good, 1.5 to 2.5 is Good, 2.5 to 4.0 is Moderate, 4.0 to 5.5 is Poor, and over 5.5 is Very Poor. Within a day of New Moon (NM), high sun noise can make conditions Very Poor regardless of the DGRD.

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The information and accompanying table are printed here in CQ VHF *on a non-exclusive basis courtesy of Derwin King, W5LUU*

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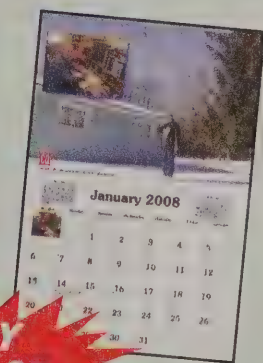

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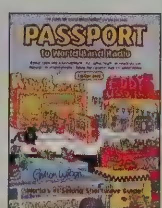

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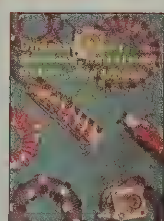

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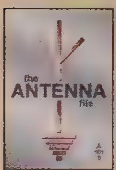

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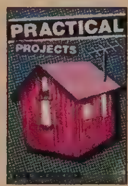

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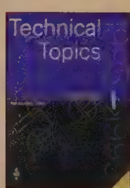

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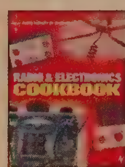

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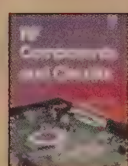

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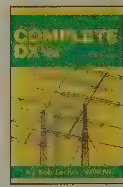

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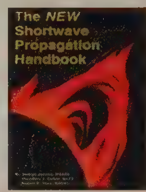

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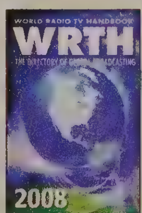

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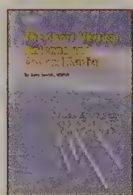

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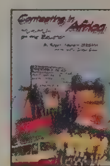

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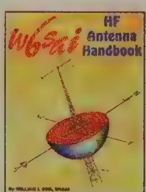

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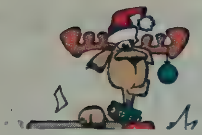

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The Lost Letters of KH6UK

Part 2 – The VHF Moonbounce Years (1958–1959)

In part 1 of this three-part series in the summer issue of *CQ VHF*, WA2VVA discussed how he came across the lost letters of Tommy Thomas, KH6UK, along with Tommy's QSO with W6NLZ. Tommy's story continues here in part 2 with a discussion of his efforts on EME.

By Mark Morrison,* WA2VVA

Tommy Thomas, KH6UK, once commented to Walt Morrison, W2CXY, that the inversion season in Hawaii was the same as on the east coast of the U.S., from July to September. Therefore, it was during the winter months that Tommy did the routine work of maintaining old antennas and making new ones.

Following the successful 144-MHz tropo season of 1957, John Chambers, W6NLZ, suggested to Tommy that he prepare for 220-MHz tests the following year. At the same time, other hams in W6-land—including W6PJA, W6AJF, K6QFI, W6DNG, and W6WSQ—were asking Tommy for schedules on 144 MHz. Tommy obliged both interests by building an array for 220 MHz and replacing his existing 144-MHz array with an even bigger one. This larger antenna would serve as Tommy's entry into serious moonbounce tests.

Tommy had been thinking about moonbounce ever since landing on Hawaii. The only thing holding him back was his not knowing exactly what to build. Tommy would write many letters to other hams working on the "moondoggle," as he called it, asking for test results of their various antenna designs. Jim Kmosko, W2NLY, and Herb Johnson, W6KQI, were testing Long John Yagis of unconventional element spacing. John, W5VWU, was pushing circularly polarized arrays. Walt, W2CXY, was testing Long John Yagis with more conventional parameters. Fran, W2OPQ, was evaluating UHF resonator colinears. And Ross Bateman, W4AO, one of the first amateurs to hear his own echoes off the moon in 1953, was using stacked rhombics. Whatever kind of antenna Tommy built would depend largely on the testing performed by these other amateurs. Not having time to experiment on his own, it was essential that Tommy listen to what they had to say.

From the very beginning, Tommy was concerned about having enough antenna gain for moon-reflection work. At first he considered 25 dB to be the minimum gain required. In a letter to W2CXY he put it this way:

> The gain of 25 dB in the antenna as a requirement for a Moon Bounce signal may or may not be correct. The Amateurs have always done better than it was supposed possible.

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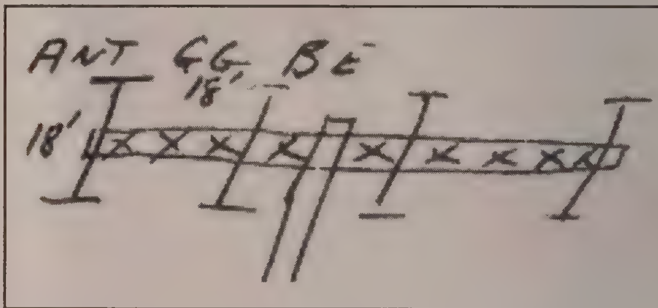


Figure 1. The sketch of what Tommy had in mind for a moonbounce array in October 1957.

Later, based upon what little information existed at the time, and the results of amateur testing where echoes had been heard, he conceded that 20 dB might be enough. Still, he used to wonder why some stations could hear their own echoes but not be heard by others, and why these same stations could only hear their echoes when the moon was low on the horizon. With the exception of Ross, W4AO, all such stations were using four Long Johns of one type or another, with gains on the order of 20 dB.

Tommy was also concerned about the high winds at his seaside location in Kahuku. When Tommy put up his first antenna for 144-MHz tropo testing, he placed it high up on a utility pole where it was subject to these high winds. Concerned that an even larger antenna might not survive the winds, Tommy took the advice of Walt, W2CXY, by placing his antenna close to the ground:

> I think I agree the thing to do is to put up something fairly big on the stick and to build a big array like you plan—near the ground where you can tilt it and where it isn't apt to blow down.

In the end, Tommy decided on a 2×4 array of eight Long John antennas with two-wavelength spacing between each antenna. Such a large array would certainly address Tommy's concerns about antenna gain, but brought new concerns about mechanical integrity. Tommy described his latest project in a letter from October 1957 (see Figure 1).

> I am on the verge of ordering 8 Big Berthas from Gonset but then there is the problem of the boom—probably need some alum. Tower

Photo A. KH6UK's moonbounce antenna array in August 1958.

sections for that—and would probably have to order those from the Mainland as doubt if they carry them out here. Maybe circular polarization would be the answer—someone should try it. Sort of hate to load myself up with a lot of stuff that I will have to jetison when I had back east next fall.

In December 1957 Tommy reported that one obstacle still remained, that of tilting his array:

Work is progressing slowly on my antenna due to holidays, etc. Still haven't figured a good simple way to tilt the thing. Could use some good suggestions from you guys of the Basement Lab group. I know you in particular are good at that stuff.

It appears that Tommy wasn't alone when it came to moonbounce activity on the island. In this letter he reveals that the military was working on a secret moonbounce project not far from his QTH:

That dope on Moon Bounce signal between here and the W.C. [West Coast] was supposed to have come from someone in the Navy, working on the stuff. It is supposed to be restricted—so could get no details—but understand high-power pulses were used. Maybe it was a case of transmission from KH6 land to the W.C., one say. I dunno Walt, more or less a rumor, with some basis in fact.

By the summer of 1958 Tommy had completed his moonbounce antenna and was ready for testing. Photo A is dated August 1958. Note the palm tree swaying in the wind in the lower right-hand corner of the array.

Upon close inspection of the photo, it appears that the antenna could be tilted but not rotated. The platform just beneath the antenna array appears to hold a motor with a cable that runs up to the hinged vertical masts. It does not appear that this design could be rotated, something Tommy mentioned later on. Tommy described his new antenna this way:

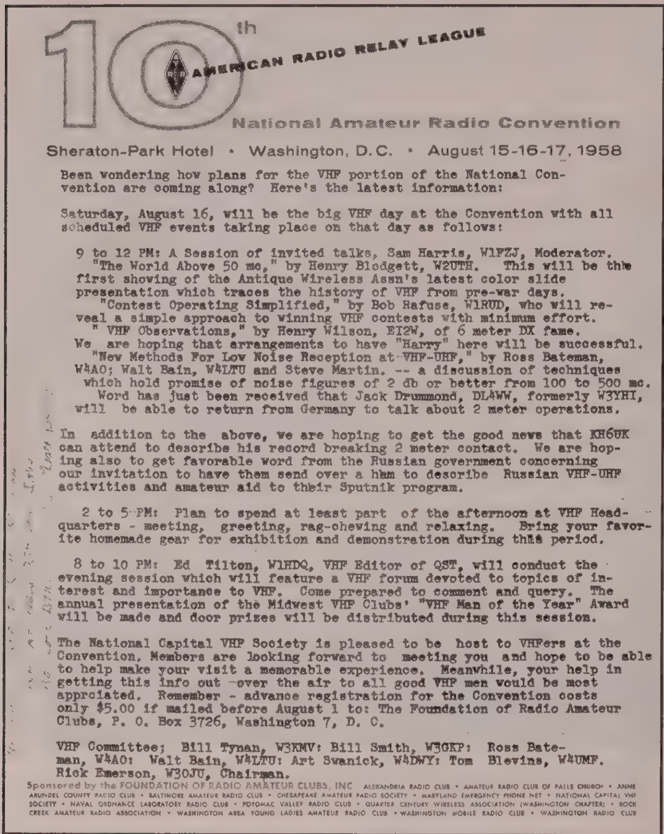
The "monster" seems OK, Walt, although I have made no attempt to check gain or pattern on it. I have no help out here as we are remotely located and no one else in this area is interested in or has had experience with 144 mcs so have to do every thing myself—except of course for the rigging, where I am extremely fortunate.

Initially, Tommy had two hams interested in serious moonbounce tests: John, W5VWU, and Walt Morrison, W2CXY. At the time it was generally believed that hearing your own echoes off the moon was a prerequisite to holding schedules with others. By the summer of 1958 neither Tommy, John, nor Walt had accomplished this task, so Tommy continued 220-MHz tropo testing with John, W6NLZ, and 144-MHz tropo testing with the other West Coast hams. These schedules kindled lasting friendships, especially with Frank Jones, W6AJF, a longtime contributor to *QST* magazine who wrote his first article in 1926 (as 6AJF!). Here is what Tommy had to say in a letter from the summer of 1958:

Moon-bounce and tropo tests with W6AJF have been non-productive to date. I have tried for my own echoes a few times but N.D. [no deal]. Hope to catch it on the horizon tonight or tomorrow and hope for better luck… Weather conditions over Pacific have not been as favorable as last year. We have lots of stormy weather this year while last year the trades were light and very little rain, etc… Frank has been a very reliable keeper of skeds and I hope for his sake we can break through for a contact one way or another. He certainly deserves it.

It was Frank who later assisted Tommy with several key components that led to UHF moonbounce success years later—something to look forward to in Part 3 of this series.

In order to keep tabs with his fellow "moonbouncers," Tommy held weekly skeds on 14.095 MHz. It was here where all the "red hot dope" could be heard and discussed, including the progress of stations hearing their own echoes and who was running schedules with whom. Tommy reported in one of his letters that W6NLZ heard a tape recording of W2NLY's 144-MHz echoes off the moon and said they were good enough for



10th AMERICAN RADIO RELAY LEAGUE

National Amateur Radio Convention

Sheraton-Park Hotel • Washington, D.C. • August 15-16-17, 1958

Been wondering how plans for the VHF portion of the National Convention are coming along? Here's the latest information:

Saturday, August 16, will be the big VHF day at the Convention with all scheduled VHF events taking place on that day as follows:

9 to 12 PM: A Session of invited talks, Sam Harris, W1FZJ, Moderator. "The World Above 50 mc," by Henry Blodgett, W2UTH. This will be the first showing of the Antique Wireless Assn's latest color slide presentation which traces the history of VHF from pre-war days. "Contest Operating Simplified," by Bob Hafuse, W1RUD, who will reveal a simple approach to winning VHF contests with minimum effort. " VHF Observations," by Henry Wilson, EI2W, of 6 meter DX fame. We are hoping that arrangements to have "Harry" here will be successful. "New Methods For Low Noise Reception at VHF-UHF," by Ross Bateman, W4AO; Walt Bain, W4LTU and Steve Martin. -- a discussion of techniques which hold promise of noise figures of 2 db or better from 100 to 500 mc. Word has just been received that Jack Drummond, DL4WW, formerly W3YHI, will be able to return from Germany to talk about 2 meter operations.

In addition to the above, we are hoping to get the good news that KH6UK can attend to describe his record breaking 2 meter contact. We are hoping also to get favorable word from the Russian government concerning our invitation to have them send over a ham to describe Russian VHF-UHF activities and amateur aid to their Sputnik program.

2 to 5 PM: Plan to spend at least part of the afternoon at VHF Headquarters - meeting, greeting, rag-chewing and relaxing. Bring your favorite homemade gear for exhibition and demonstration during this period.

8 to 10 PM: Ed Tilton, W1HDQ, VHF Editor of QST, will conduct the evening session which will feature a VHF forum devoted to topics of interest and importance to VHF. Come prepared to comment and query. The annual presentation of the Midwest VHF Clubs' "VHF Man of the Year" Award will be made and door prizes will be distributed during this session.

The National Capital VHF Society is pleased to be host to VHFers at the Convention. Members are looking forward to meeting you and hope to be able to help make your visit a memorable experience. Meanwhile, your help in getting this info out over the air to all good VHF men would be most appreciated. Remember - advance registration for the Convention costs only $5.00 if mailed before August 1 to: The Foundation of Radio Amateur Clubs, P. O. Box 3726, Washington 7, D. C.

VHF Committee; Bill Tynan, W3KMV: Bill Smith, W3GKP: Ross Bateman, W4AO: Walt Bain, W4LTU: Art Swanick, W4DWY: Tom Blevins, W4UMF. Rick Emerson, W3OJU, Chairman.

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Figure 2. A copy of the 1958 ARRL National Convention leaflet anticipating Tommy's visit to Washington, DC.

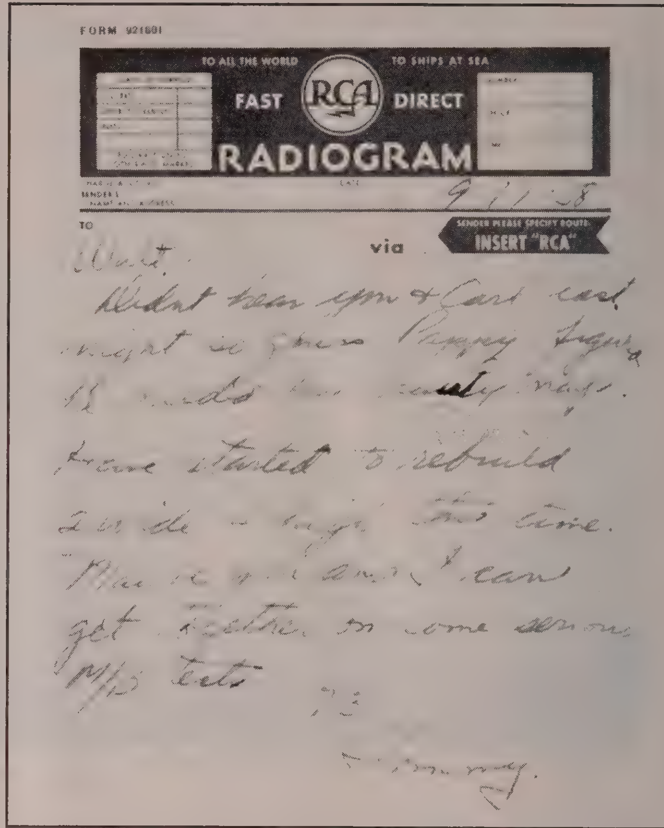

Figure 3. In this note Tommy suggested that Walt, W2CXY, should get ready for serious moonbounce tests.

a QSO. In another letter Tommy mentioned that Walt Bain, W4LTU, was in the Washington area at that time and maybe getting ready for skeds with Jim, W2NLY. Tommy also mentioned that the boys in W4 land, most likely W4AO and W4LTU, had been twisting his arm to attend the National Convention in Washington, DC. Figure 2 is a copy of the ARRL National Convention leaflet that shows that Tommy's visit was much anticipated. Note the handwritten note from Walt Bain, W4LTU, to Walt Morrison, W2CXY, on the left-hand side.

Later that summer Tommy updated Walt on the moonbounce progress of John, W5VWU:

> John, W5VWU, reports hearing his own echoes for about 4 mins at moon-set the other night. Only time he has heard anything and nil when the moon is high in the sky.

In September 1958 Tommy reported that he was rebuilding his 144-MHz array, this time 2 wide by 4 high. Such an unusual configuration would have made tilting the array much easier, possibly even by hand. Figure 3 is a note, written on RCA Company stationary, in which Tommy suggests once again that Walt, W2CXY, should get ready for serious moonbounce tests.

By December 1958 Tommy reported that his new antenna should be much stronger than the original, suggesting that the winds of Kahuku had plagued his original "2 over 4" design:

> I guess I will proceed with my plans to rebuild the array using eight 23 ft. Yagis—2 wide and 4 high. Have new heavier tower section for the upright sections and going to use the older/lighter sections for cross members. This will make a much stronger job and only hope it isn't too heavy.

Tommy also provided more information on that secret Navy MB circuit:

> The Navy is now installing two 85 ft. dishes out here for MB ckt [moonbounce circuit] with Wash DC so if we don't hurry up they will beat us to the punch. The one used for rcvg will be installed only a few miles from here … somehow or other Walt you have to get something [better] up than the four 24 footers, good as they are… I am going to try to get all set by 1st April so you can figger accordingly.

Figure 4, from "Satellite to Semaphore" published by the International Telecommunication Union in 1965, illustrates the Navy's Hawaii to Washington, DC EME (Earth-Moon-Earth) circuit.

Finally, Tommy reported that his receiving setup would benefit from some additional gain thanks to the efforts of W6AJF:

> Thanks for all the dope on converters, par [power?], amps, etc.—all sound very intriguing and hope they produce. We sure have to find some way to pick up some more decibels on the VHF bands. W6AJF is bldg a par amp job and maybe he will have some info on our sked tomorrow. I work him on Mondays on 21 Mc to keep in touch until we ready to get going again on 2 meters.

On June 22, 1959 Tommy made the first two-way contact with John, W6NLZ, on 220 MHz, establishing a world's DX record that stands to this very day. Following that success, Tommy and Helyne left Hawaii for their first vacation in four years. While vacationing in Miami in December 1959, Tommy wrote W2CXY a letter, parts of which are reproduced in the accompanying sidebar. What is significant about this letter is

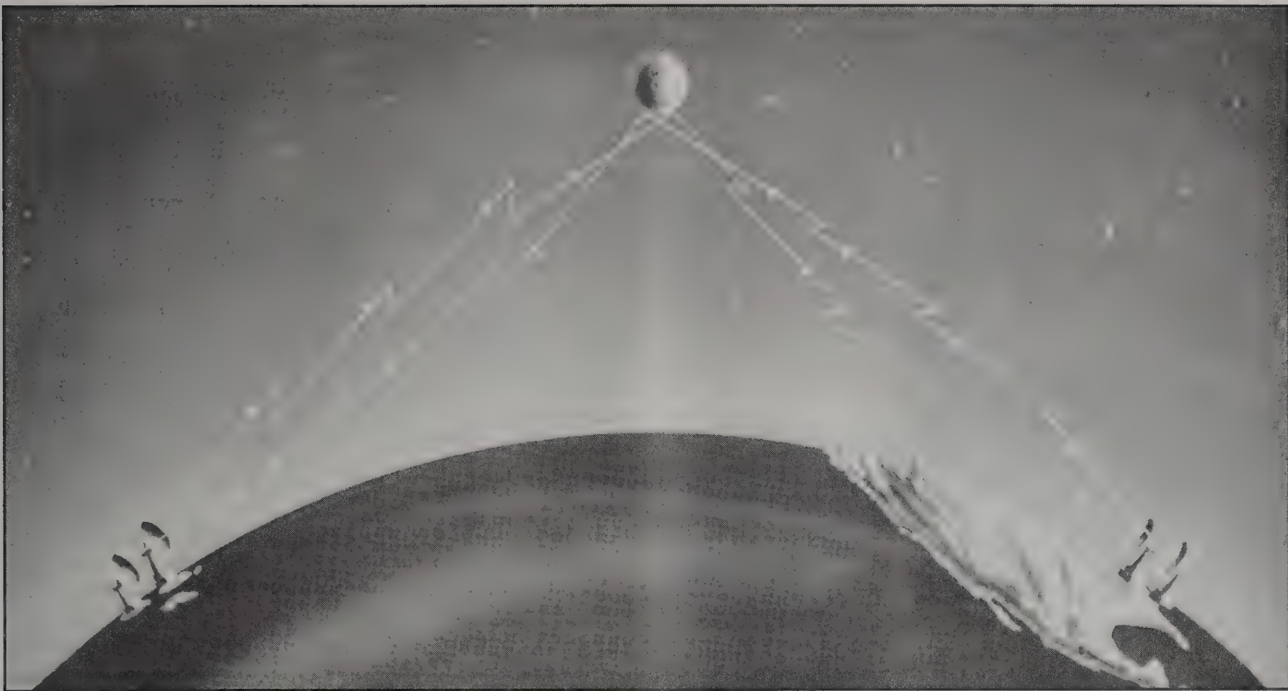

Figure 4. The Navy's Hawaii to Washington, DC EME circuit. (From "Satellite to Semaphore," published by the ITU in 1965)

that it may be the last one written by Tommy in the 1950s, an historic decade that witnessed many changes in amateur VHF communications, including the first meteor-scatter QSO, the first use of passive satellites for reflection work, record-breaking tropospheric work, advances in weak-signal work, amateur participation in the IGY (International Geophysical Year), and the very first amateur reflections off the moon, some of which were pioneered by Tommy and his friends, including Ross Bateman, W4AO, Paul Wilson, W4HHK, Carl Scheideler, W2AZL, and Walt Morrison, W2CXY. This letter hints at the influence that Tommy wielded, even outside amateur circles, something that would be needed in the years ahead. Part 3 of this article picks up in 1960 with the rest of Tommy's moonbounce story.

The Last Lost Letter of the '50s

This is probably the last lost letter from Tommy during the 1950s decade:

23 Dec 59
Miami, FL

Hi Walt,

Am sitting out on the lawn enjoying the balcony breezes while scribbling this letter to you. Sorry we couldn't get together for one more confab before we left as there are several things in connection with M/B we should have discussed. The meeting with the boys in Wn [Washington DC] was very enjoyable but produced nothing concrete. Ross was out of town—darn it. Anyway that info you already have from Ross should give us enough— with what we already know—to go ahead with. Carl [W2AZL] was going to give you my Miami address so you could mail me a copy of Ross's letter but I'll bet he forgot all about it as I have looked for it in vain. As we plan to leave here this weekend for the West Coast better mail it to me c/o W6AJF as I will visit him on way back.

Let me have the dope on the antenna as soon as possible so I can get started on it. I am going to forget the big dishes for a while as they are too much work, etc., and only worth while for 400 Mc or higher. About all the time I will have available will be taken up with trying to get across on 432 Mc and with our M/B project. Will have my hands full getting set up and running skeds on these bands in 1960—anything higher will have to wait til 1961—don't expect to do anything further on 220 Mc just now.

Sorry I couldn't accomplish more with MARS in Wn. for you—but just didn't have the time—and things didn't click like I had hoped. One of the men I counted on was on vacation & Chief [of] MARS is being re-assigned shortly. Did have a meeting with head of the Army Communications tho and he said they were much interested in our work and to let him know if they could be of any assistance. Top Brass—these boys! Nice to know our work is recognized and appreciated in the right quarters!

Well, Walt, let me hear from you—either via W6AJF or direct to Kahuku. Should be back there around Feb 1st at latest as want to [get] started as soon as possible. Best to Carl.

Aloha & 73

Tommy KH6UK

By Bob Witte,* KØNR

The 2007 Colorado 14er Event

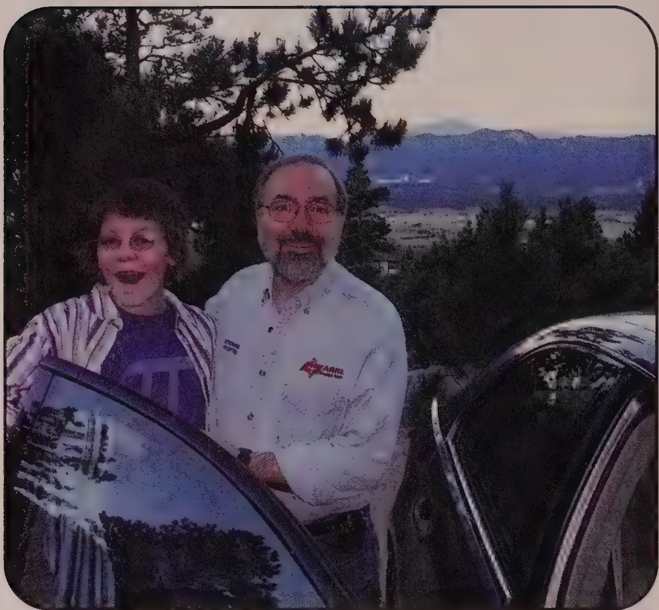

Photo A. Stephen, KCØFTQ, and Steve, KDØBIM, about to depart from home. (Photo via KCØFTQ)

The Colorado 14er Event originated from a simple concept: Let's all go out and operate from Colorado's highest mountains on the same day. Many amateur radio operators like to take along handheld or portable transceivers when they hike or climb, so a little bit of organization was all it took to create this annual event. There are 54 summits in Colorado recognized as distinct 14,000-foot (or higher) mountains, commonly referred to as "14ers." Most of the mountains require a strenuous climb, but a few can be driven up. This year I operated from Pikes Peak, a drive-up summit close to Colorado Springs.

The road to the summit of Pikes Peak was originally a carriage road, dating back to 1889. Later, an automobile road was constructed on the same route, which today is operated by the City of Colorado Springs as a toll road. The 19-mile Pikes Peak Highway is paved part of the way, with gravel on the remaining section of the road. It is not a terribly difficult drive, but your vehicle has to be in good running condition and you need to be tolerant of tight corners and *very* steep drop-offs.

In preparation for this year's event (August 12), I contacted my group of "usual suspects" to see who wanted to activate Pikes. The assembled crew turned out to be me, my wife Joyce, KØJJW, Stephen, KCØFTQ, and his son Steve (no radio license at the time). Actually, Steve had just passed his Technician class exam, but the FCC had not yet issued him a callsign. No problem, as we'd give Steve his chance to operate with one of us acting as control operator. Our usual practice is to operate under the club callsign KØYB, which is short and easy to understand on the air.

As I rolled out of bed at 5 AM, I thought about the hams out climbing who were on the trail by then. Any thought of complaining about getting up early faded quickly as I thought about the *real mountaintop operators* out there. The typical 14er climb includes 4,000 feet in vertical change and 4 miles in distance. Some are easier, some are harder . . . none are trivial.

I had loaded the SUV with all of the radio gear the night before and the fuel tank was topped off. A short time later, Joyce and I were cruising west on Highway 24 towards the Pikes Peak Highway. We reached the toll gate at 7 AM, where there was a line of cars waiting for the road to open. We headed up the road and arrived at the summit around 8:30 AM. We contacted Stephen and Steve on 147.42 MHz on our way up and determined that they were just a few miles behind us (Photo A). The primary operating hours for the event are from 9 AM to noon, designed to allow time for the climbers to make it to the summit and then retreat before the afternoon thunderstorms roll in. We wanted to be set up and operating no later than 9 AM.

Mount Harvard

The day before, Chris KØCAO and his wife Kelli had left the North Cottonwood Creek Trailhead and backpacked about 5 miles, camping at an elevation of 12,000 feet (Photo B). This camping spot positioned them well to finish off the remaining 1.5 miles to the summit of Mount Harvard in the morning. This is a great strategy for a hike-in summit—break the hike into two parts by camping part way up the trail. At 7:00 AM they were on the trail and they made the summit at around 8:30 AM. This gave them plenty of operating time ahead of any potential afternoon thunderstorms.

Chris used his dualband FM handheld transceiver to make radio contact from the summit (Photo C). In all, Chris worked nine other radio operators on 14ers and made about 20 QSOs. Chris also had taken along a signaling mirror and used that to flash other nearby mountaintops. (This has become a secondary activity for some of the 14er operators where mountaintops are close together.) Kelli and Chris made a video of their climb, available on the YouTube.com website (see references and Photo D).

At 14,420 feet above sea level, Mount Harvard is the third highest peak in Colorado. This peak was named by Josiah Whitney, while leading a group of students from Harvard up the peak in 1869. Whitney was a professor at Harvard but he grad-

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K4S from Mount Sunflower, Kansas

By Bruce Frahm, KØBJ*

The first K4S effort by the Sand Hills and Trojan ARCs was in 2006. The goal was to activate the highest point in Kansas, Mount Sunflower, especially for the Colorado 14er radio event and it was a limited-time operation. At only 4039 feet above sea level and a mere two-thirds of a mile from Colorado, this gentle knoll in a pasture presents a laughable scene when compared to the Colorado 14ers location on Pikes Peak. Thus, we laughed our way to success and fun! Whether describing our "struggles" with altitude sickness and arduous climbing, or speculating on the odds that a newly minted cow pie would ratchet our elevation up a foot, we had fun sharing our surroundings during our 20-meter and VHF/ UHF QSOs.

Both clubs draw members from a wide, sparsely populated area and Mt. Sunflower lies between the two. It's about an 80-mile drive for most members. We occasionally team up to activate Mt. Sunflower, and the cooperative effort affords great camaraderie. We had a nice complement of VHF/UHF equipment in 2006, but committed an error by staging the entire expedition on Sunday. By the time we were on the air, many of the 14ers were descending their locations, and we only contacted three groups. What we did experience was lots of interest and welcoming by the 14ers. Being 10,000 feet higher, actually in Colorado and (in most instances) having *climbed* to get to their operating positions, they could have "laughed us off the face of the Earth," but instead they were interested and appreciative. HF certificate chasers were also eager to work us.

This year we had limited crew and equipment available, but we did arrive on Saturday for setup. Bob, KCØWJT, and Bruce, KØBJ, overnighted at "summit camp" in Bob's pull trailer (his family performs Bluegrass music, so the trailer has been the scene of prior harmonics and modulation—of audio frequencies). HF QSOs mainly on 20 meters SSB attracted interest on Saturday evening. A great short-skip opening to Missouri and even southeast Kansas put some acquaintances in the log. We also worked into Kansas City on 2 meters SSB. The lack of any towns for a considerable distance brought an awesome Milky Way enriched sky after night fell and the *Perseids* meteors punctuated the scene.

Sunday morning just after sunrise Ray, KCØZSM, and Jim, KCØZSH, arrived. We switched our 11-element 2-meter Yagi from horizontal to vertical and got serious about looking for 14ers. Being ready early paid off, and we logged KØYB and KØNR from Pike's Peak; K5BIL and NØXGZ from Mt. Evans; KCØYIH on Mt. Sherman; NØXDW from Mt. Bross; and KØNA on Mt. Bierstadt. We also snagged WO9S mobile in Nebraska; KG6TDB at home in Ft. Collins; and eked out a marginal QSO with ABØTX in Newton, Kansas. We narrowly missed logging KØCAO on Mt. Harvard. We're fascinated with his video clip of receiving us and QSOing others, available at <http://video.google.com/videoplay?docid=-6446083004152361265>. On Sunday HF activity didn't ignite like it had on Saturday night, but all told 140 HF QSOs went in the log.

The heart of our equipment complement is a 50-foot tower trailer. This crankup/tiltover beast was given to the Wheat Belt Radio Club a half century ago by a TV dealer who had used it for demos of that new invention to rural folks in the 1950s. It's been a mainstay of western Kansas Field Days and VHF bivouac sites ever since. An old Cushcraft HF tribander, 11-element 2-meter Hy-Gain, and two homebrew tape-measure Yagis graced the tower and the camper's awning.

The K4S (Kansas 4er Sunflower) 2007 crew—neophytes Ray and Jim, budding op Bob, and 40-year ham Bruce—appreciate those who QSOed us. Special thanks to the ARRL VEC for arranging the Special Event call and Jodi, KA1JPA, for getting our info into the ARRL's online Special Events list on short notice. And thanks again to the Ed Herold family, who allow public access to Mt. Sunflower. QSL to WØWOB.

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uated from Yale, so he made it a point to name another nearby 14er Mount Yale.

Back on Pikes Peak, when we arrived at the summit, the first priority was to get the 2-meter FM station up and running. This band and mode are the most popular for this event, since most of the hikers carry FM handheld radios. Our 2-meter FM station consisted of a Kenwood TM-231A transceiver connected to a Diamond X-50 vertical antenna. Usually the action is fast enough on the band that an omnidirectional vertical (with a little gain) works better than having to deal with rotating a Yagi antenna. We inserted a DCI bandpass 2-meter filter in the transmission

Photo B. Chris, KØCAO, walking up the trail to Mount Harvard with backpack. (Photo via KØCAO)

Photo C. Chris, KØCAO, making radio contact from the summit of Mount Harvard. (Photo via KØCAO)

Photo D. Chris, KØCAO, and wife Kelli standing on the summit of Mount Harvard. (Photo via KØCAO)

line to help suppress interference on the peak. Since for the annual event there are multiple transmitters up there, I've had problems in the past with my transceiver getting overloaded by all of the RF energy. The TM-231A didn't have a hint of a problem with the filter installed.

The X-50 antenna was placed on the top of three sections of RadioShack standard TV mast, held by a homemade drive-on mount (Photo E). The drive-on mount is a piece of 2 × 8 lumber with a short piece of pipe held by a floor flange. The pipe is just the right size to let the TV mast slip over it. This is a common portable operating technique, useful for special events, portable operation, and emergency communications.

We had Steve operating the 2-meter FM rig, with his dad supervising as control operator (Photo F). This was Steve's first real radio operation and he sounded like a pro. He called "CQ 14er Event, this is Kilo Zero Yankee Bravo on Pikes Peak" as if he had been doing it for years. He was able to click through contacts at a fast rate, using the right phonetics and operating procedures. I think his dad got to make a few contacts, but the majority of the contacts from Pikes Peak were made by young Steve.

Our SUV housed the other station, which covered 2-meter SSB using a Yaesu FT-100 driving an M^2 9M2 horizontally polarized Yagi. We used a special mount that fits into the 2-inch hitch receiver and is sized to hold a standard TV mast vertically (Photo G). This vehicle also housed the 222-MHz FM station and the 440-MHz FM station, both using mag-mount antennas on the vehicle's roof. The 222-MHz rig was an old ICOM IC-32A recently acquired via eBay. A Yaesu FT-50 covered the 440-MHz band for us.

For power, we used a Honda AC generator. This provided a steady power source and eliminated the hassle of relying on the vehicle battery. The generator ran very quietly and did not have a problem with running at that high altitude. (Driving to a mountain's summit does have its benefits.)

Mount Sunflower

Long before we arrived at the summit of Pikes Peak, another mountaintop radio operation was already in place from another high "peak." The Trojan Amateur Radio Club was operating a special event station using the callsign K4S from the highest point in Kansas: Mount Sunflower. At an elevation of 4,039 feet, Sunflower is lower than most of the state of Colorado. However, these brave souls fought the elements and risked exposure to oxygen deprivation to activate this Kansas peak (Photo H). They asked for our understanding, since they don't have 14ers (14,000 foot mountains) in Kansas. They refer to Mount Sunflower as a "4er," hence the callsign K4S (Photo I).

We knew about the planned Sunflower operation, so we wanted to be sure to work them during the event. This was one of the reasons for taking along the 2-meter SSB rig and a decent Yagi antenna. Mount Sunflower is about 160 miles east of Pikes Peak, so I expected to work them easily on 2-meter SSB. It turned out that the Yagi wasn't necessary. While we were setting up, I heard K4S calling on the 14er event calling frequency—147.42 MHz FM. I had the mobile rig monitoring this frequency using a not-so-optimal 1/4-wave antenna mounted on the hood of the vehicle. We easily worked them using the vehicle's FM rig and the

Photo E. The mast for the 2-meter FM antenna on Pikes Peak was held in place by a drive-on mount. (Photo via KØNR)

Photo G. Joyce, KØJJW, setting up the 2-meter Yagi while Bob, KØNR, supervises. (Photo via KCØFTQ)

simple antenna. The K4S crew was running about 50 watts to an 11-element Yagi on 2 meters, so they were putting out a really nice signal. They were coming in quite strong on Pikes Peak all morning.

The Mount Sunflower crew had set up Field Day style, camping out for the weekend. They operated two stations, one on VHF and one on HF. The radio crew at Mount Sunflower included

Photo F. Steve on Pikes Peak operating the 2-meter FM rig like a pro! (Photo via KØNR)

Photo H. The Mount Sunflower operation in western Kansas. (Photo via KØBJ)

Photo J. Jim, KCØZSH, operating VHF from the K4S Special Event station. The official Mount Sunflower marker can be seen in the background (Photo via KØBJ)

Bob, KCØWJT, and Jim, KCØZSH, on the VHF station (Photo J), while Bruce, KØBJ, and Ray, KCØZSM, handled the HF rig.

Making the Contacts

On Pikes Peak, Steve kept racking up the 2-meter FM contacts at a decent pace, while Joyce and I filled in on 440 MHz and 222 MHz. I fired up the 2-meter SSB station on 144.200 MHz a few times and worked a handful of stations on that mode. I didn't operate there all of the time, as I knew it would interfere with the 2-meter FM station. Any band and mode can be used during the event and some of the 14er operators set up HF stations. Still, most of the fun is on the VHF and UHF bands.

In the end we made a total of 77 QSOs:

Band	QSOs
2-meter FM	50
2-meter SSB	3
222 MHz FM	4
440 MHz FM	20
Total	77

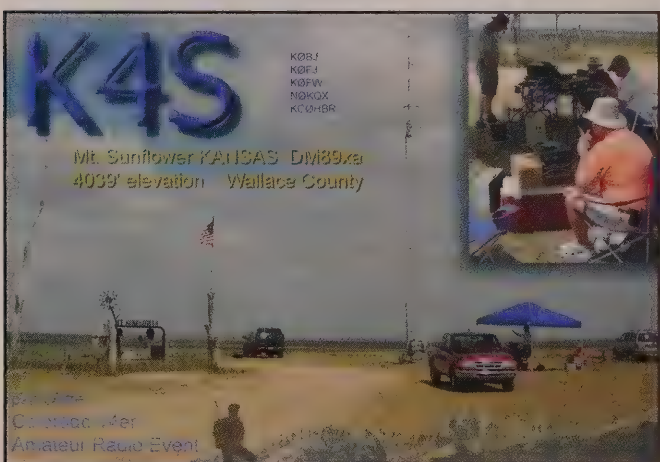

Photo I. The K4S Special Event QSL card from 2006. (Courtesy of KØBJ)

We worked hams on the summits of the following 14ers: Sherman, Evans, Antero, Harvard, Torreys, Grays, Bierstadt, Quandary, and Bross. We also worked a number of operators who were out hilltopping on smaller peaks. Our best DX was the K4S station on Mount Sunflower.

Pikes Peak is an especially good location for this event. It towers over Colorado Springs and has a line-of-sight path up to Denver, Boulder, and Fort Collins. At the same time, it has a good shot to all of the 14ers around the state. This can cause an interesting pile-up effect, as the station on Pikes Peak can hear almost every station in the event but they can't hear each other. Sometimes the QRM gets a little intense with multiple stations transmitting on the same frequency. With the capture effect of FM, the strongest signal usually wins, wiping out the weaker and more distant ones. Just when you are trying to work that weak station on one of the distant mountains, someone nearby fires up their 50-watt mobile rig and covers them up.

Around 12:30 we tore down the stations and packed up our gear. We stopped for our traditional picnic lunch at the Halfway Picnic Area, relaxed, and discussed the results of the radio operation. We all agreed that this is a great event that allows hams to get on the air and have some fun.

A few days later, I received an e-mail telling us that Steve was officially licensed as KDØBIM. Congratulations, Steve!

The next Colorado 14er Event will be held August 10, 2008.

73, Bob, KØNR

References

The Colorado 14er Event website: <http:// www.14er.org>

Pikes Peak Highway website: <http://www.pikespeakcolorado.com/>

Video of the Mt. Harvard climb: <http://video.google.com/videoplay?docid=-6446083004152361265>

USA's 2007 ARDF Championships and Emergency Transmitter News

"World-class radio-orienteers shouldn't have to sleep in unheated garages!" That was the good-natured complaint of Jay Hennigan, WB6RDV, at breakfast on the first competition day of this year's national Amateur Radio Direction Finding Championships (ARDF). He was recovering from a night in a rustic cabin near the shore of Lake Tahoe in the Sierra Mountains of east central California. The temperature had dipped into the 30s overnight, but was heading for the 70s under clear skies.

Jay went on to win a gold medal in the category for men age 50 to 59. He had to navigate with map and compass through the forest from the start line to the finish while finding all required transmitters (four in his category) in the least elapsed time. A typical course is five to eight kilometers long, if you travel the shortest possible route. Vadim Afonkin of Boston, the day's fastest, did it in an hour and two minutes. Others took up to three hours, which was the time limit for this hunt.

This 2-meter competition took place on Saturday, September 15. The next day there was a similar competition on the 80-meter band in a different part of the forest. Both courses were set by Bob Cooley, KF6VSE, of Pleasanton, California. A long-time orienteer, Bob used the experience he gained in 2003 when he mapped the area and helped set courses for the national championships of the US Orienteering Federation.

General Chair of this year's championships was Marvin Johnston, KE6HTS, of the Santa Barbara Amateur Radio Club. SBARC teamed up with the Los Angeles Orienteering Club (LAOC) to organize the events and to set up electronic scoring. Maps were provided by the Bay Area Orienteering Club. International Amateur Radio Union (IARU) rules for ARDF were followed as closely as possible.[1]

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Bob Cooley, KF6VSE, set all courses for the 2007 USA/IARU-R2 Championships and for two days of intense training prior to the event. (All photos by the author)

These Seventh USA ARDF Championships were combined with the Fourth ARDF Championships for IARU Region 2 (North and South America).[2] Unfortunately, the USA was the only Region 2 country represented. The foreign visitors came from Germany in Region 1 and Australia in Region 3. For the second year, Nick Roethe, DF1FO, and his wife Brigitte included the USA Championships in their auto touring of the US.

SBARC looked forward to even more foreign visitor participation, including two hams from Mongolia and five from the Ukraine, but it was not to be. Their entry visas to the USA were denied. Although no reason for the refusal was given, it is believed to be related to the statistically higher percentage of "jumped" visas from some countries. The denials came two weeks before the championships, which was too late for the appeal process.

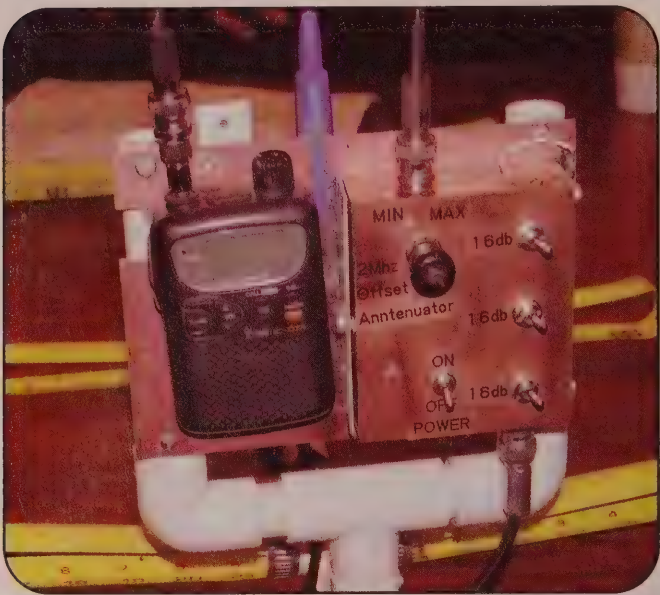
One competitor who had no trouble gaining entry to the US was Bryan Ackerly, VK3YNG. He has been coming to ARDF events on our continent since the first IARU Region 2 Championships in 1999 near Portland, Oregon. Over the years, he has shed pounds and gained speed to become a world-class performer. His time in the 80-meter event was the best overall at the championships. Afterwards, he had enough stamina to run back onto the course for another hour, just to take photos of the other competitors.

On arrival, two days before the 2-meter hunt, Bryan got over his jet lag by hiking 10 miles round trip from Camp Concord to the top of Mount Tallac, 9,735 feet above sea level. Since there was no food at the camp when he got back, he went for another 10-mile run into town and back again.

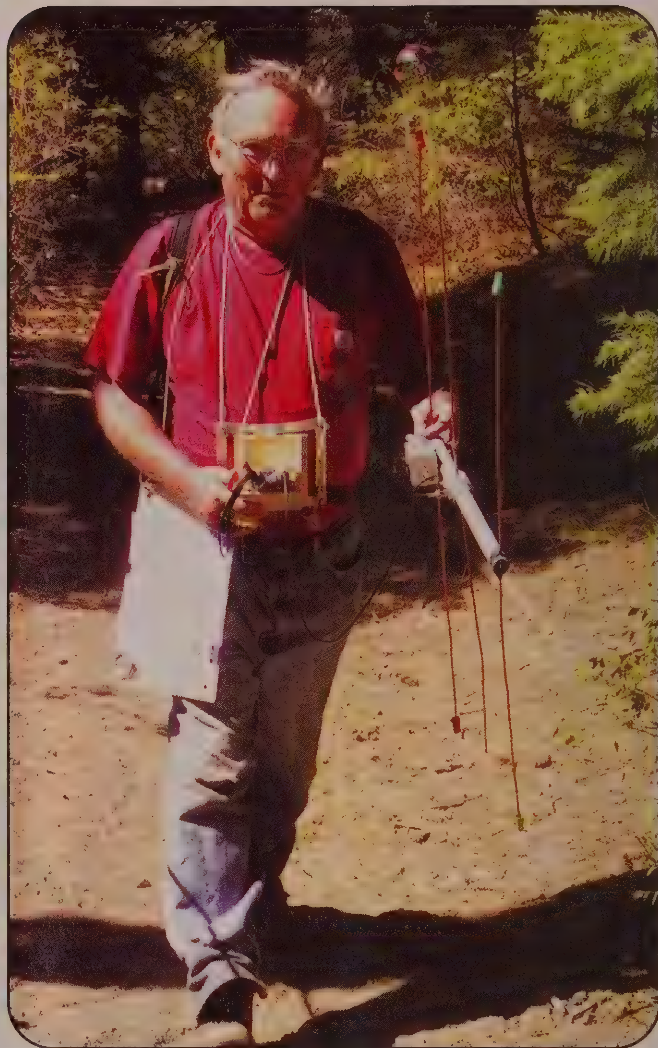
VK3YNG and other foxhunters in the Melbourne area enjoy on-foot ARDF and vehicular foxhunting almost equally. When Bryan is not out tracking radio foxes, he makes and sells a small VHF receiver designed especially for ARDF (more on that later).

This is the second time that SBARC and LAOC have organized the USA ARDF Championships under the direction of KE6HTS. In 2004, the event was headquartered in Gorman, California, at the top of Tejon Pass, halfway between Burbank and Bakersfield. The 2-meter competition was at Vasquez Rocks State Park and the 80-meter hunt was in the forest of Mt. Pinos, near Frazier Park.

To bring and keep radio-orienteers together as much as possible, KE6HTS and KF6VSE chose Camp Concord for the



This is how Paul Gruettner, WB9ODQ, mounted his small handie-talkie and active attenuator to his 2-meter RDF antenna.



Neil Robin, WA7NBF, in the 2-meter starting corridor. He carried his receiver in a neck harness. His home-built 2-meter Yagi has stiff wire elements instead of the more typical steel measuring tape. Note the wire nuts for eye protection at the element ends.

2007 event headquarters. This 29-acre facility is owned and operated by the Community and Recreation Services Department of Concord, California, 25 miles northeast of downtown San Francisco and a 170-mile drive from the camp.

Camp Concord, which is celebrating its 40th year, hosts over 600 children every summer in six one-week sessions that include swimming, archery, sailing, horseback riding, and leadership exercises. A separate foundation provides funding for families who otherwise could not afford to send their kids there. Even the counselors do not know which kids are on such scholarships and which are not. At the same time, in the other half of the facility, family camp is taking place.

As I talked with Camp Director Marylou Chopelas about her fine programs, I imagined how wonderful it would be if amateur radio operating and hidden-transmitter hunting were included in the regular summertime activities for youth and families. That would take lots of effort and ongoing support from hams in El Dorado County. How about it?

Radio Sporting Goods

Every competitor at the championships had his or her own vision of the optimum 2-meter RDF setup. It was hard to find two identical sets of equipment, unless they belonged to members of the same family. Those who first experienced ARDF in Europe tended to prefer one-piece receiver-antenna units from the Ukraine or Russia. They typically have a continuous tuning dial covering 144 to 146 MHz, sometimes modified to go up to 148 MHz for the Western Hemisphere.[3]

These European sets have AM detectors because that mode is standard for ARDF on that continent. They have relatively wide IF stages, so they often experience interference from other strong 2-meter signals in urban areas. This was not a problem in the forests of eastern California, however.

The most popular ready-to-use RDF set in Australia and the USA is Sniffer 4, designed and produced as a side business by VK3YNG. Bryan brought several with him on the trip and they were quickly snapped up. Sniffer 4 covers the full American 2-meter band and the VHF aircraft band. Frequencies are entered in the usual four-digit way, so punching in “F6565” sets it to the USA T-hunting frequency of 146.565 MHz and “F2150” brings up the 121.5 MHz aircraft ELT frequency. A touch of the mode button changes the output between AM and FM reception on either band.

Australian foxhunters like tone-pitch signal-strength indicators. They call it the *whoopee mode* because of the “wheeee-oop” sound as the beam is swept across an incoming signal. Sniffer 4 has a high-sensitivity whoopee response, making it easy to find the peak or null direction.

As you approach a radio fox and the signal gets stronger, Sniffer 4 automatically increases the input RF attenuation in range steps of about 15 dB each and beeps to tell you when a range change has taken place. The single-digit indicator displays the current attenuation range. When the signal goes off-air, attenuation drops to zero in two seconds (adjustable between one and five seconds)

The term "sniffer" implies a receiver with reduced sensitivity and selectivity, intended primarily for closing in on strong signals. However, in my tests the whoopie indicator would easily detect a 2-microvolt signal on 2 meters. That's not quite as sensitive as most handie-talkies, but it's more than adequate to hear all the foxes on an international course with a three-element beam. At the other end, a 100-millivolt signal (maximum output of my bench RF generator) only registered in the "5" range on the 9-step attenuator. Even next to fox transmitter antennas, the unit doesn't get swamped.

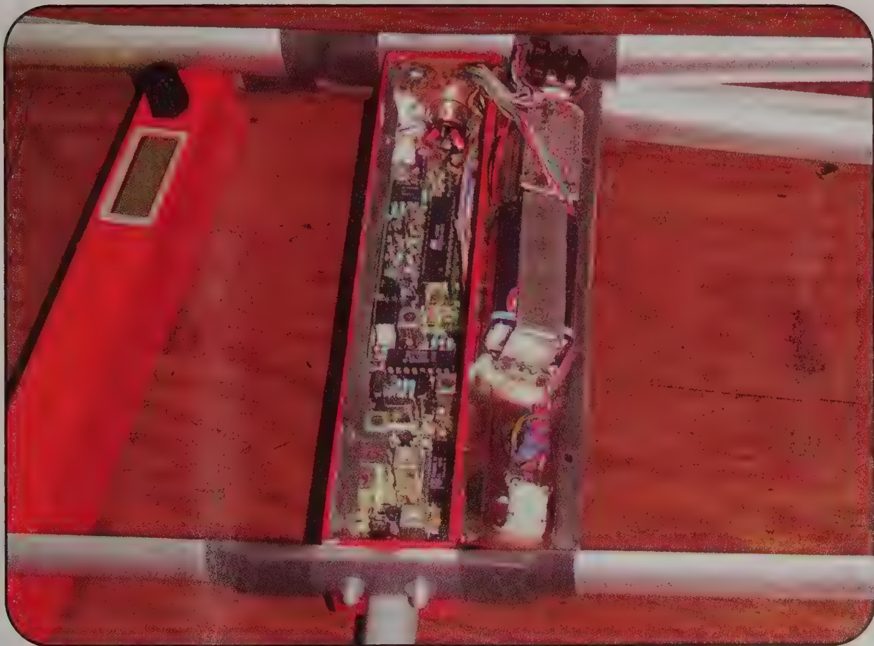
Changing batteries necessitates removing four screws to open the back of the unit—not something to do in the middle of a hunt. Two AA alkaline cells will power Sniffer 4 for about three hours, depending on audio volume, indicator brightness, and whether you wear headphones. Lithium AA batteries will keep it going for about 14 hours. Nickel-cadmium (Ni-Cd) or nickel metal hydride (Ni-MH) cells aren't an option, because their terminal voltages are too low.

Like most microprocessor-controlled radios, there are bells and whistles for advanced users, such as a memory to tell you the maximum attenuation value achieved since the last frequency change or power-up. There's also a 0–99% battery-remaining indicator, automatic volume reduction when the battery gets low, and a low-tone whoopee option for persons with poor high-frequency hearing.

A popular feature for five-fox international-rules competitions is the built-in timer. Synchronize it to the start of fox #1 and it will beep a warning ten seconds before the end of each fox's transmission, then beep out the number of the next fox to transmit. At switchover time, it immediately resets the attenuation to zero so you are ready if the next fox is weak.

Sniffer 4 supports stereo headphones. In one ear you get whoopee tone and in the other signal audio so you know which transmitter is on the air. For more information, download the complete manual on the web.[4]

In my experience, Sniffer 4 is ideal for teaching RDF to newcomers, youth, and Scouts. I tell them to simply turn the beam for the highest pitch at the highest number. However, for some serious hunters that's too much automation. They prefer to manually dial in the RF attenuation as they approach foxes. Sniffer 4 has a mode for this. Almost as effective, if you have a 2-meter handheld receiver with S-meter, is to use it with an external offset attenuator.[5] Make provisions to mount both the receiver and attenuator to the antenna for one-hand operation in the woods.



Nick Roethe, DF1FO, built this 2-meter ARDF receiver into the boom of his RDF Yagi.

Yagis of three or four elements give much better bearings in reflection-prone terrain, compared to two-element Yagis or HB9CV-type phased arrays. Foxhunters who build their own usually choose tape-measure designs for flexibility and safety in the brush.[6] WB6RDV is an exception, preferring his four-element log-periodic with braid-over-fiberglass elements.

Tracking 406-MHz Rescue Beacons

As I write this column, searchers continue to look for aviator Steve Fossett, who has been missing since September 3. It was reported that his aircraft had an Emergency Locator Transmitter (ELT) and that he wore a Breitling Emergency watch.[7] However, no emergency signals have been heard directly or via satellite.

Aircraft ELTs are designed to activate automatically on impact, but there are estimates that they fail to do so about a third of the time. What's worse, ELTs activate falsely during hard landings and at other inappropriate times. I don't know if it is true, but a story has been circulating on the Internet about employees of an aircraft manufacturer who are said to have "borrowed" a life raft from the production line to go on a river trip. Hours later, a Coast Guard helicopter appeared overhead to "rescue" them because the raft carried a beacon that had activated without their knowledge.

Even if that story is fiction, it's a fact that an overwhelming majority of the activations of ELTs and Emergency Position Indicating Radio Beacons (EPIRBs) are accidental or non-emergency related. When it happens, the continuous 121.5- and 243-MHz signal is picked up by SARSAT/COSPAS satellites and relayed to the Air Force Rescue Coordination Center (AFRCC), which determines the approximate location using Doppler shift of the signals as received at the satellites. AFRCC notifies the agency responsible for response in the area of the "hit." An effort must be made to track each activated beacon, not just because it's possible that lives are in danger, but to clear the frequency for other activations.

New 406-MHz EPIRBS transmit a burst of data that includes traceable unit identification and the option of GPS coordinates. Because of their widespread acceptance, and because of the high costs of investigating false hits, the International COSPAS/SARSAT Organization is scheduled to stop satellite processing of anonymous 121.5- and 243-MHz signals on February 1, 2009. The satellites will continue to relay the identification and GPS coordinates transmitted by the

new 406-MHz beacons. Although the National Transportation Safety Board strongly recommends that all aircraft be retrofitted with new 406-MHz ELTs, and has asked the Federal Aviation Administration to make this mandatory, the FAA has not issued such a ruling so far. The Aircraft Owners and Pilots Association is on record as opposing it.

Despite the reluctance of agencies to mandate a switchover to 406-MHz beacons, they are rapidly gaining popularity. Beginning four years ago, FCC regulations permit the sale of Personal Locator Beacons (PLBs), which are identical in most respects to ELTs and EPIRBs, but are marketed to hikers and sportsmen for terrestrial use.

ARDF Championships 2007 – A Perspective

By Neil Robin, WA7NBF

Neil Robin, WA7NFB, participated in the M60 class in the 2-meter competition and won the bronze medal.

This is a brief report on the US National and Regional ARDF Championships held at Lake Tahoe during September 14–16, 2007. This event was sponsored by the Los Angeles Orienteering Club along with the Santa Barbara Amateur Radio Club.

Radio orienteering is a sport that is much more popular in Europe and other parts of the world but slowly gaining interest in the US. It combines orienteering with radio direction finding. You may ask, "What is orienteering?" In short, its the athletic ability to travel cross country to multiple control points in the minimum amount of time. At each control point there is a type of recording device to show that you reached that point and your elapsed time. Control points are only made known when you reach the "starting gate." Of course, you can travel through thickets, brush, swamps, or whatever to reach these points, but a smart contestant will read the special orienteering map handed him or her once in the "starting gate." Strategy is very important to work around obstacles. Most will make use of trails and roads to cover large distances quickly. A web source of more information on orienteering can be found at: <http://en. wikipedia.org/wiki/Orienteering>.

Radio orienteering changes "control points" to hidden radio transmitters (foxes). You have to use radio direction finding (RDF) skills to locate these new points, and then punch the clock as you reach them. When you're handed the map, only the terrain is shown, not the location of the transmitters. You must use your RDF skills to build your strategy and minimize the time needed to find all the required transmitters yet avoid obstacles along the way. Transmitters will almost always be hidden in the bush, not near trails or roads. Of course, VHF radio signals bounce a lot, so taking bearings is a developed skill. The winner is the one who finds the required number for his or her class in the least time. This arrangement is called ARDF, or Amateur Radio Direction Finding, and involves international rules. The US is part of IARU Region 2, but we use Region 1 rules.

Orienteering maps are built from topographical maps, but symbols and legends are added to show detail that potentially limits travel or helps identify positions. Once you start to travel cross country, you will almost always become lost in a matter of minutes. You no longer know exactly where you are. Using the features of the map in coordination with what you see will help you re-establish or at least estimate your location. For me, half the fun is figuring out where you are. Figure 1 is an example of a map.

The color coding is much different from topo maps. Dark green is very rough terrain with cross-country travel being discouraged. The "starting gate" is located in the lower left corner as a purple triangle. The circle surrounding the start is the "exclusion zone" with a radius of 750 meters. No transmitters will be found within this area. The "finish" is the two concentric circles. No transmitters will be found within 400 meters of each other or the "finish." That's what the smaller circle is all about. When you're handed the map, you could guess where up to five transmitters are located, but you will need RDF to pinpoint them over each 5-minute re-cycle period. The challenge is to reach each required and return to the finish in the least amount of time and before the course overall duration expires. Map legends can be found at this link: <http://www.williams.edu/Biology/Faculty_Staff/hwilliams/Orienteering/map.html>.

Orienteering map used in 2-meter hunt showing only the start and finish points.

In southern California, the Civil Air Patrol (CAP) is responsible for responding to all satellite-relayed emergency beacon activations. Two of the area's most active CAP members are Bob Miller, N6ZHZ, and Cathy Livoni, KD6CYG, who go on many ham radio transmitter hunts as practice for their search-and-rescue direction-finding. Bob reports that time to locate 406-MHz ELTs with GPS assistance is usually much faster that finding 121/243-MHz ELTs by RDF. However, there are instances when there is no GPS data on 406 MHz, or it's inaccurate, and the 121/243-MHz signals from the same ELT fail or can't be copied. Then the RDF has to be done on 406 MHz.

Transmissions from a 406-MHz ELT are 5 watts or more, giving greater range than typical 100-milliwatt VHF ELTs. The bursts can be as short as 440 milliseconds and occur at about 50-second intervals. If you have ever tried to track a low-rate pulse transmission with a directional antenna such as a Yagi, or with a dual-antenna RDF set, you know that it's very difficult. You can't sweep the beam through a full azimuth circle in less than a half-second. It can take many minutes to get enough transmissions for a reliable bearing.

What about using a Doppler-type RDF set to track these PLB bursts? Dopplers have the advantage of making hundreds of "virtual sweeps" every second. However, the minimum transmission time for accurate bearing determination is a function of the set's audio filtering and detection circuits. It is not instantaneous.

Most Dopplers have high-Q switched-capacitor filters. They are heavily damped to provide the narrowest possible audio passband.[8] Ideally, the filter would pass only the detected Doppler tone frequency, which is the same as the frequency of antenna pseudo-rotation. If it were wider, the data modulation on the signal would introduce errors in bearing readout. Unfortunately, these high-Q filters are slow to acquire and resolve the Doppler tone. N6ZHZ reports that his Doppler, a commercial unit from a well-known company, consistently gives bearing errors of 90 degrees on his practice 406-MHz EPIRB, even though bearings on continuous signals in the same frequency range are accurate.

Digital signal processing (DSP) may be the path to Doppler RDF accuracy on short-burst data-modulated signals such as UHF distress beacons. I have corresponded with two DSP design experts who are experimenting with it. Doppler filters contain "garbage" at signal acquisition, which must be quickly and com-

The international rules control many aspects of the hunt: Rules and information can be found at: <http://members.aol.com/homingin/intlfox.html#rules>. No use of GPS is allowed, and it's an individual sport relying only on map, compass, and RDF skills. You can't attempt it as a team, so you must travel alone, but all have enough skills that getting truly lost is rare indeed.

My Results

I only entered the 2-meter competition. Although Dale Hunt, WB6BYU, loaned me an 80-meter receiver, I didn't put the time into learning how to use it so I could compete effectively. Nearly all competitors were experienced enough that my practice was very important for any success that I could expect. Propagation on 80 meters works differently than on 2 meters in that you don't have the reflections, but you also don't have a good indication of signal strength. In a practice session I completely walked around a transmitter but couldn't tell how far away it was. It turned out that I was nearly on top of it but didn't know that at the time. Experience helps a lot!

I won the bronze medal for my M60 class in the 2-meter competition. It wasn't hard, because the M60 class had few competitors since this is a race that requires considerable physical endurance, which discourages older participants. Being an insulin-dependent diabetic, I didn't want to push myself at the 6,500-ft. altitude of Lake Tahoe, so I took a long two-hour time to get to the finish. I was very pleased that I received the bronze medal and have the utmost respect for the serious runners. Most have been at it for several years.

The best of the US team still rarely wins world-class metals. The Europeans, particularly the Ukrainians, are the ones to beat on the world stage. Orienteering and radio orienteering are sports in which their high school students participate, so it's a very common activity for them as they grow up.

Attendees included Brian Ackerly, VK3YNG, from Australia. Brian is most noted for his design and manufacture of the Sniffer 4 two-meter foxhunting receiver. Brian is so good that he competed in a lower age class just so he had to find all five transmitters. He won the "gold" in that class!

One member told of disturbing a bear that was sleeping on one hunt. I am sure glad that the bear didn't follow him to the finish line!

Bryan Ackerly, VK3YNG, had the best time for the five-fox course on Sunday. He is the designer and builder of the popular Sniffer 4 RDF receiver, which covers 2 meters and the aircraft band.

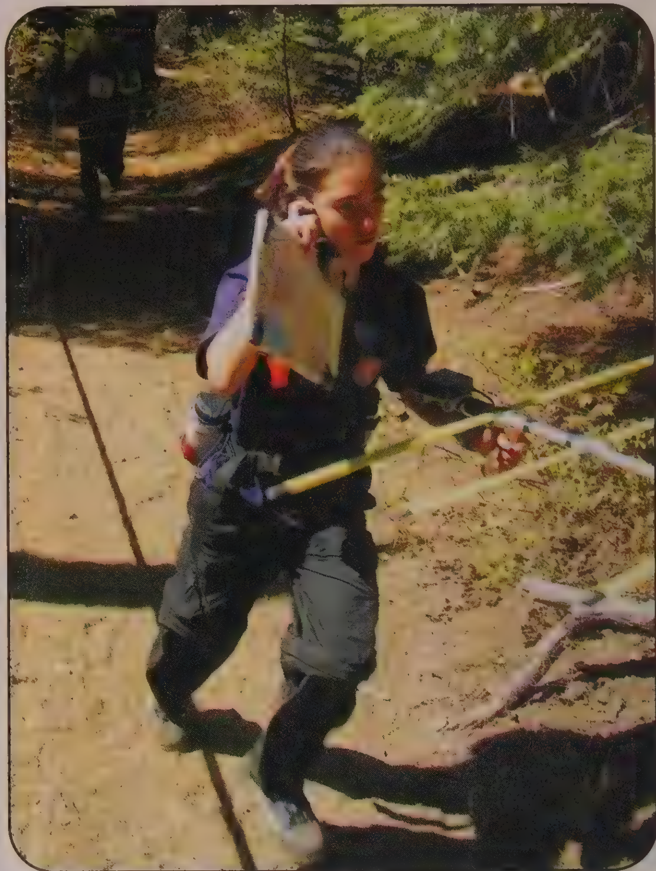
pletely pushed out and replaced by signal data to prevent erroneous bearings. DSP holds promise for accomplishing this at high speed. I welcome your ideas and will report on progress in future "Homing In" columns. It may even be possible to make Dopplers work well on the 20-millisecond pulses from wildlife research tags.

More TracMe® News

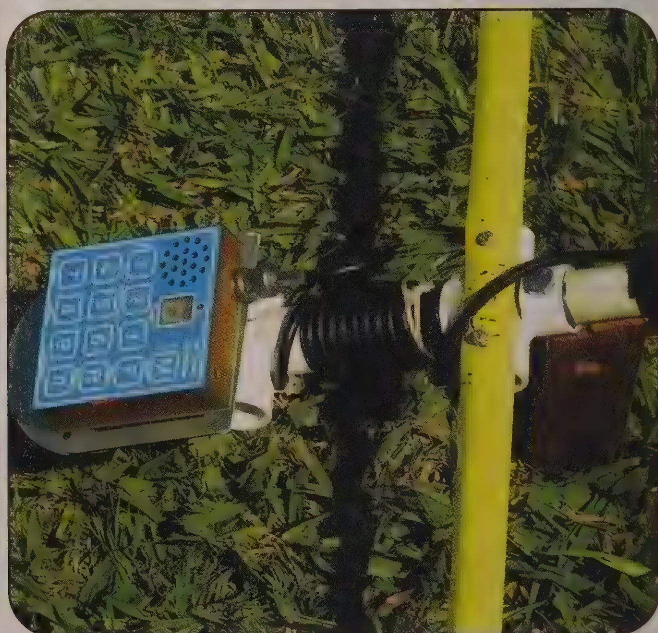
In the Spring 2007 issue of *CQ VHF*, I reported that TracMe® Beacons, an Australian company, is introducing a lower-cost alternative to satellite-tracked PLBs. A TracMe transmitter sends a recorded voice call for help at 10 milliwatts on Family Radio Service (FRS) Channel 1. TracMe is not offering FRS RDF equipment for sale to the public at this time, so my column delved into equipment and techniques that hams and other searchers can use to locate these devices when activated.

Not surprisingly, TracMe's product has stirred controversy. Its cost is attractive, but there is concern that buyers will confuse TracMe with satellite-tracked PLBs, thinking that activation will automatically trigger a rescue effort.

While a TracMe might guide rescuers to you, it is betting against the odds to expect it to be an effective alerting device. Aircraft pilots monitor 121.5 MHz, not FRS Channel 1. Someone must be in ground range of the 10-milliwatt UHF signal, this person must have a FRS radio tuned to Channel 1, the channel must be clear of QRM, and the radio's CTCSS function must be turned off so that your non-CTCSS signal isn't squelched. The listener must believe that the recorded call for



At age 12, Monique Beringer was the youngest competitor at the USA Championships. Here she is running through the starting corridor with my measuring-tape Yagi and Sniffer 4 receiver.



My Sniffer 4 is mounted on a swivel plate behind the reflector of the Yagi so that it can be face-up for either horizontal or vertical polarization. Note the coax choke balun to optimize the directional pattern and the wooden handle at the balance point to avoid wrist strain.

CQ's 6 Meter and Satellite WAZ Awards

(As of October 1, 2007)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28.29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26.29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

ARHAB 20th Anniversary Celebration

Amateur radio balloon groups converged on Findlay, Ohio this past August 11th to celebrate the 20th anniversary of the first Amateur Radio High Altitude Balloon (ARHAB) flight in the U.S. Five balloons were launched in the morning from the same location as my first flight at the farm of George Flinchbaugh, WA8HDX.

Ham radio payloads were flown by Nick Stich, KØNMS, Robert Rochte, KC8UCH, Taylor University (KB9ZNZ), and me (WB8ELK). In addition, the University of Akron and Taylor U flew experiments using a 900-MHz spread-spectrum downlink, and members of the University of Tennessee, Knoxville ARC balloon group (AA4UT) were in attendance for the launch and chase, but didn't fly their experiment. (See Photo A.)

Some very unique payloads were flown during the event. Nick, KØNMS, flew his license-free Garmin Rino unit, which performed extremely well (Photo B). These are handheld units with embedded GPS that transmit position on an FRS/GMRS channel to other handheld units. Even from 30 miles away, we had great reception using just an identical handheld Rino on the ground. Taylor U and University of Akron flew a 900-MHz SS (spread spectrum) system that provided high-speed data links that worked well. I flew one of my first ATV payloads (live TV camera with GPS overlay). After 20 flights up to the edge of space and back, the package consists mostly of duct tape . . . after all, real science is not possible without duct tape!

I also flew a simplex repeater on 2 meters using an Alinco DJ-S11T and a RadioShack simplex repeater module. Quite a few folks from several states were able to work through it. Taylor U flew a crossband FM repeater (2 meters and 70 cm). The Ft. Wayne ARC operated net control for the repeater, and it was in constant use from launch to landing with excellent signals across a large portion of the Midwest.

Four of the balloons were launched at the same time, and some of them made it to almost 100,000 feet. They all landed about 30 miles south of the launch site and were recovered a few miles apart from one another. Quite a few balloon trackers were on the chase, and after tromping through acres of soybeans and trying to pry payloads from balloon-eating trees, all of the payloads were recovered in good shape (Photo C).

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Photo A. Four balloons launch at once at the 20th Amateur Radio High Altitude Balloon (ARHAB) celebration.

Photo B. Nick Stich, KØNMS, demonstrates his Rino tracking payload.

Photo D. Robert Rochte, KC8UCH, launches his Superpressure balloon.

Photo C. The recovery team after a successful chase and recovery (l to r): Joe Demeyer, KD8EYH; Dave Snyder, KB8PVR; Mike Ricksecker, W8MDR; Greg Williams, K4HSM; David Hoffman, KE4FGW; Janice Hoffman; and Nick Stich, KØNMS.

Photo E. Spencer devours the near space dog biscuit.

In addition to the four latex weather-balloon launches, Robert, KC8UCH, brought along a unique new Superpressure balloon that he designed and built (Photo D). Basically a Mylar™ cylinder that overpressures to float at a particular altitude for long durations, he attached a 5-ounce APRS system consisting of a Byonics Microtrak300, GPS receiver, and a pair of lithium 9-volt batteries. Keeping things as lightweight and simple as possible, his payload was packaged in a mailing envelope. Robert's balloon turned out to have quite a ride, as it floated for hours at 7,000 feet and came down in the wee hours of the night near Lexington, Kentucky. To everyone's surprise, it came back to life the next morning as the sun warmed it up and off it went for another day's flight, eventually coming down at sunset in a rugged area just east of Bowling Green, Kentucky. As luck would have it, his payload landed near a highway and someone driving by recovered the payload shortly after it landed. The balloon actually lifted off for a third flight after he cut free the APRS payload.

I've flown some intriguing experiments over the years, including a batch of "Peeps in Space," but this time Brian Tanner's dog Spencer wanted to fly an experiment of his own. Spencer wanted to see if a dog biscuit tasted better if it had been flown to the edge of space. The answer apparently is a resounding *yes* (Photo E).

Special thanks go out to Joe Brown, WB8MSJ, for transporting all the helium tanks and George Flinchbaugh, WA8HDX, for the use of his farm.

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Back to the Basics

Once in a while it is good to go back and review the multifaceted topic of amateur radio satellites and answer some of the many questions that come up over and over on the AMSAT nets, at hamfests, and at club meetings. I will try out a Question and Answer format to accomplish this communication. I can't ask and answer all of the questions heard over the years, but I will try to hit the most prominent ones. The answers are covered in the literature and in some cases contain my opinions. Naturally, there are several correct answers to some of these questions.

Q: Are amateur radio satellites new? How long have they been around?

A: The first amateur radio satellite was Orbiting Satellite Carrying Amateur Radio 1, or OSCAR-1. It was launched on December 12, 1961 from Vandenberg Air Force Base in California and circled the Earth transmitting the Morse code letters "HI" on the 2-meter amateur band. It was battery powered and transmitted until the batteries ran down. The speed of the Morse characters was proportional to the temperature of the satellite.

Q: How many amateur radio satellites have been launched? How many are still active?

A: At the present time, the OSCAR designation has been awarded to 61 satellites and the RS (Radiosputnik) designation to 18 that I know of. There have been numerous CUBEsats launched that achieved orbit; I estimate 21. This brings the grand total to 100. A score card is maintained on the AMSAT web page. As satellites come and go, approximately 12 are operational at any given time. This activity level has been maintained for several years now. In the beginning, we were lucky to have one at a time.

Q: Who builds the amateur radio satellites and how are they financed?

A: Amateur radio satellites are built primarily by volunteers for AMSAT organizations worldwide and by students at schools and universities. Most of the AMSAT "Birds" are financed by donations from individuals around the world. In many cases the donations are for products such as software, books, clothing, etc. In some cases donations, "in kind," of equipment, services, launch opportunities, and so on, have come from corporations, foundations, government agencies, and other groups. Many of the satellites built by schools and universities have been at least partially financed by education grants. We have long since left the period of the "free launch," so we must now raise all or a significant part of the money for our launches.

Q: Who controls the satellites? Must I have a separate license to operate on them?

A: By regulation, satellites are licensed in the country of their manufacture. The group that builds them generally maintains a command station or a network of command stations. Hams throughout the world regularly are asked for help gathering telemetry to aid the command stations and using agencies (school projects). Your amateur radio license is all of the authority you will need to work or use the satellites. Membership in the organizations that build and maintain the satellites is desirable but is not usually necessary.

Q: What is the minimum amount of equipment necessary to operate on satellites?

A: The absolute minimum is a dual-band FM HT covering the 2-meter and 70-cm bands. In general, you will need a receiver for the satellite downlink and a transmitter for the uplink. These can be separate units or combined within the same unit. The minimum antenna would be a long "rubber duckie." For some satellites, equipment that is capable of SSB and/or CW is necessary. There are also other specialized modes available.

Q: What about antennas? Is a large dish necessary?

A: In general, not even a small dish is necessary. Most of the current satellites have uplinks and downlinks on the 2-meter and 70-cm bands where conventional antennas are usable. For the LEO (Low Earth Orbit) satellites, omni-directional antennas can be used with success, particularly if a pre-amp is used on the receive side. Small Yagis are very beneficial; however, with any directive antenna comes the necessity to steer it in, at least, the azimuth dimension. As we go up in frequency, small dishes, helicals, loop Yagis, corner reflectors, Lindenblads, and patches are popular. For HEO (High Earth Orbit) satellites, higher gain antennas are necessary, along with the requirement to steer them in both azimuth and elevation.

Q: Okay, I'm hooked. What equipment would be necessary to form the basis of a good all-mode satellite station capable of using all of the "Birds?"

A: First you will need a good multimode transceiver capable of simultaneous operation on (at least) 2 meters and 70 cm. Two separate multimode transceivers for these bands can be used instead. Transceivers such as the ICOM IC-910H, Yaesu FT-847, and Kenwood TS-2000 will fill this requirement. Some

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of the newer generation multimode transceivers, such as the FT-817, can be utilized if two of them are used. Older multimode separates such as the IC-275 and IC-475 will fill the bill. Many other older radios such as the FT-726, FT-736, IC-970, and TS-790 can still be used as well; however, the capability to computer-control these radios varies and may not be as good as the current generation models. Some of these radios can be purchased with additional bands—for example, 1200 MHz can be included or "plugged in." A more versatile way to add other bands is to add out-board transverters or converters.

An antenna mount that is steer able in azimuth and elevation will be required. It should be of a size such that it can handle antennas for 2 meters, 70 cm, and various microwave bands, along with space for transverters, converters, mast-mounted pre-amps, power supplies, etc.

Also, don't forget quality transmission lines and connectors along with adequate weather proofing.

Q: Is a computer necessary to operate on the satellites? What software is required?

A: Years ago I always "hedged" on the first part of this question. Today I will say yes. The first thing you need a computer for is to predict when and where your satellite will be available to work. This can be done either with a good satellite tracking program in your computer or you can go to several online sites on the Internet. You can also get Keplerian data for your favorite satellites from the Internet.

Second, a computer is very useful for automating a station. With proper interfacing, it can also control your antennas, compensate for Doppler shift, and do telemetry capture and decoding. Interface hardware and software is much more readily available than it was just a few years ago.

Q: What is the difference between LEO and HEO satellites and what are the characteristics of each?

A: Low Earth Orbit, or LEO, satellites are generally in circular orbits at altitudes ranging from 300 to 2000 km. Most often they are in polar, 90-degree inclination, or near polar orbit. Quite a few, including the ISS (International Space Station), are at inclination angles of 50 to 60 degrees. They make a large number of orbits (14 to 16) per day, of which you will see 4 to 10 in range of your QTH depending upon station latitude. Each pass will last for 7 to 20 minutes, depending upon satellite altitude and how close to an overhead pass you have.

High Earth Orbit, or HEO, satellites may be in circular orbits (GPS and geosynchronous satellites) or elliptical orbits, such as the Russian Molynia and variations of this one. The apogee (high altitude) part of the orbit may be 30,000 to 60,000 km) and the perigee (low altitude) part of the orbit is usually around 1000 to 1500 km. Amateur radio satellites such as AO-10, AO-13, and AO-40 were in this type of orbit and permitted operation for 8 to 10 hours a day and worldwide coverage. AMSAT's vision is to have continuous, worldwide coverage through satellites of this type by the year 2012. The Phase 3E satellite from Germany and the Eagle satellite from AMSAT-NA will fulfill this vision when they are launched in high enough numbers.

Q: Why can't I simply lock my antennas in place like my satellite TV dish and forget it? Will I ever be able to do this?

A: All of the current amateur radio satellites are in orbits such that they are constantly in motion relative to your QTH; therefore, your antennas must move. TV satellites are in a circular orbit over the equator at an altitude (32,000 km) such that they always maintain a fixed relationship to a point on the equator, and thus a constant pointing angle to your QTH. This special orbit is known as *geosynchronous*. Naturally, it is a popular orbit for commercial purposes. It is also relatively expensive to achieve and maintain. So far amateur radio has not been able to afford this orbit; however, there is hope that space in a geosynchronous satellite may be available at a reasonable cost in the near future as costs come down and excess space becomes available.

Summary

Operation on the amateur radio satellites has never been easier than or as affordable as it is now. Yes, it can be challenging, but it is well within the capabilities of most hams if they will just allow themselves to think about it. No, you don't have to be a rocket scientist to operate on amateur radio satellites. However, if you will simply allow yourself to keep an open mind and learn while using them, you may *become* a rocket scientist. If you think of additional questions you would like for me to answer, please contact me.

73, Keith, W5IU

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

New AMSAT Lab Completes First "Satellite"

Where would you build a ham satellite? At the dawn of the Space Age, OSCARs 1 and 2, the very first amateur radio satellites, were lashed together in the garages of a handful of dedicated San Francisco Bay Area hams. The next few OSCARs went together in more professionally equipped commercial laboratories, thanks to the generosity (and, in some cases, the ignorance) of various amateurs' employers. Still later, universities and colleges became home to satellite construction efforts, a trend that continues to this day. Still, for its most ambitious projects, AMSAT has required a more formal Satellite Integration Facility to carry out the final phases of space hardware construction and testing. We've boasted two such facilities in our nearly three-decade history, the first in the famous fishbowl at the NASA Goddard Spaceflight Center in Maryland, and later, another in a hangar on the Orlando Executive Airport in Florida. Now, AMSAT satellite integration activities enjoy a new home.

As reported in a past column, AMSAT recently forged a productive partnership with the University of Maryland Eastern Shore (UMES), which resulted in our acquiring a spacious satellite lab. The arrangement is decidedly synergistic: AMSAT owns a clean-room large enough to house our biggest satellites, which had long been in storage in Florida, but with no place to set it up. UMES, on the other hand, occupies a large building a little south of Salisbury, Maryland, but with no clean-room to set up there. The agreement now in place allows UMES to house and use our clean-room for its satellite projects, on a non-interference basis with AMSAT activities. This clearly benefits us all.

But wait, there's more! If you order now, in addition to the full set of Ginsu knives, you also get this unprecedented educational partnership….

That's right. In the words of last winter's AMSAT press release: "The agreement with UMES calls for AMSAT-NA to work collaboratively with UMES to identify opportunities to work together on satellite and related technology projects as well as to work with their students and faculty to enhance hands-on studies and dissertation research. The possibility also exists for AMSAT-NA scientists and engineers to receive Adjunct status at the UMES." In other words, we now have not just a new landlord, but a new educational partner (hence, the inclusion of this item in the "Orbital Classroom" column).

Therefore, it happened that in January of 2007 three rented vans full of equipment were driven north from Orlando, to join up with half-a-dozen AMSAT volunteers at the new facility in Maryland. Our stated mission was to unload the trucks and start setting up our new lab. However, given a spacious new facility, who could resist the urge to throw a satellite together? Certainly not AMSAT!

Duct tape is like "The Force": It has a dark side and a light side, and it binds the universe together.

The inspiration for CoasterSat I came from the table amenities at the local restaurant where UMES and AMSAT volunteers gathered for dinner the evening before move-in day. Someone noticed that the square coasters upon which our (adult) beverages were place measured roughly ten centimeters on a side. "Hey, that's the size of a CubeSat," your author opined. Thus, the rather large die was cast.

Since no Jedi or AMSAT away-team ever goes anywhere without a roll of duct tape, it didn't take long for CoasterSat to take shape. Looking around the table for solar cells to line its exterior, our gaze fell upon a plethora of properly colored and appropriate-size artificial sweetener packets. A pair of 6-inch coffee stirrers resonated conveniently as a Vee antenna for 70 cm. Faster than you can say, "orbital insertion," a new AMSAT bird was born! The result can be seen in the accompanying photograph. Although CoasterSat may never pass its vibration and thermal-vacuum chamber tests, this project speaks to the innovative spirit fostered within AMSAT and embraced by our educational partners in Maryland.

Our next effort, integration of the most capable Eagle satellite, may take just a little longer. Nevertheless, with the support and assistance of our academic partners, we are well on our way into orbit. UMES's students gain hands-on experience. We gain new orbital assets, and maybe a few new hams along the way. Seems win-win to me. Clearly, "The Force" is with us. 73, Paul, N6TX

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By Tomas Hood,* NW7US

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

It's Open Season for Meteors

This past August did you see the *Perseids* meteor shower? Did you work any of the meteor plasma trails on amateur radio VHF (6 or 2 meters)? I've seen many reports of moderate success for operators in various regions of the world during the 2007 *Perseids* season. Along with working meteors, a mix of tropospheric ducting often occurs in some regions, and I wonder if the two propagation modes ever combine. I'm interested in hearing from you if you've observed and worked such combinations of VHF propagation.

The 2007 autumn meteor season is open for DX hunters. While the *Perseids* meteor shower is one of the impressive yearly showers, partly due to the time of year in which it appears, the showers that will occur over the next few months are great rivals.

The Next Shower

One of the largest yearly meteor showers occurs during November. Appearing to radiate out of the constellation Leo from November 10 through November 23, the *Leonids* will peak on the night of November 17 and the early morning of November 18. This shower is known to create intense meteor bursts. Since the source of the *Leonids,* the Tempel-Tuttle comet, passed closest to the sun in February of 1998, the years following were expected to produce very strong displays. The greatest display since 1998 was the peak of 3,700 meteors per hour in 1999. Every year since then has been significantly less spectacular. However, a few (lonely) forecasters think that we still might have a meteor storm with an hourly rate of thousands of meteors sometime in the next several years. The more common forecast is that we'll only have a rate of about 15 meteors per hour.

The best time to work meteor scatter off the *Leonids* is around 11:30 PM, local time, in the Northern Hemisphere. The shower should increase in rate the closer you get to midnight, and then move down toward pre-dawn.

A Possible Meteor Storm in November?

Keep alert for the *a-Monocerotids* shower, which will occur from November 15 through November 25. The peak will occur on November 22 at 0310 UTC. Normally, this shower produces about five meteors per hour, but this year it may produce a burst as high as 400 per hour. The most recent big burst was in 1995 with a reported ZHR (zenith hourly rate) of about 420. It was expected that the ten-year cycle would result in a large storm in 2005, but that never occurred. That is why we should stand ready this year, as the cycle could be longer than anticipated.

Will this be the year of a return of the storm-level activity? If so, it will make the prospect for exciting meteor-shower radio propagation probable. We just cannot know for sure, since it takes a direct interaction with the comet dust trail by the Earth in order to see such a higher rate of meteors entering the atmosphere.

The chances of Earth hitting a dust trail that is so narrow and filamentary are slim. This has proven true for most meteor showers in recent years, when we have missed various meteor trails nearly completely. During these misses, Earth slips between the clouds, where there is only a sprinkling of meteoroids.

December and January Prospects

After November, the annual *Geminids* meteor shower from December 7 to December 17 will peak on December 14 at 1645 UTC. This is one of the better showers, since as many as 120 visual meteors per hour (ZHR) may occur. It is also one of the better showers for operators trying meteor-scatter propagation from positions in North America. The *Geminids* is a great shower for the meteor-scatter mode of propagation, since one doesn't have to wait until after midnight to catch this one. The radiant rises early, but the best operating time will be after midnight local time. This shower also boasts a broad maximum, lasting nearly one whole day, so no matter where you live, you stand a decent chance of working some VHF/UHF signals off a meteor trail.

Finally, check out the *Quadrantids* from January 1 through January 5, peaking on January 4. This meteor shower is above average, and this season peaks are expected at around 120 meteors per hour. The best day should be the morning of January 4, just after midnight, and working through predawn.

Check out the website <http://www. imo.net/calendar/ > for a complete calendar of meteor showers.

Working Meteor Scatter

Meteors are particles (debris from a passing comet) ranging in size from a speck of dust to a small pebble, and some move slowly while some move fast. When you view a meteor, you typically see a streak that persists for a little while after the meteor vanishes. This "streak" is called the "train" and is basically a trail of glowing plasma left in the wake of the meteor. The meteors enter Earth's atmosphere traveling at speeds of over 158,000 miles per hour. Besides being fast, the *Leonids* usually contain a large number of very bright meteors. The trains of these bright meteors can last from several seconds to several minutes. It is typical for these trains to be created in the *E*-layer of the ionosphere.

Meteor-scatter propagation is a mode in which radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E*-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have

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been used to make successful radio contacts off these meteor trains.

Lower VHF frequencies are more stable, and contacts last longer off these ionized trails. A 6-meter contact may last from a second to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. Conversely, a meteor's ionized train that supports a 60-second refraction on 6 meters might only support 1-second refraction of a 2-meter signal. Special high-speed digital modulation modes are used on these higher frequencies to take advantage of the limited time available—for example, high-speed CW in the neighborhood of hundreds of words per minute.

A great introduction by Shelby Ennis, W8WN, on working the high-speed meteor-scatter mode can be found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. Palle Preben-Hansen, OZ1RH, wrote "Working DX on a Dead 50 MHz Band Using Meteor Scatter," a great working guide at <http://www.uksmg.org/deadband.htm>. Ted Goldthorpe, W4VHF, has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm>.

Autumn Outlook

Autumn (November through January) is a relatively quiet season, with very little if any TEP (transequatorial propagation). TEP, which tends to occur most often during the spring and fall, requires high solar activity that energizes the ionosphere enough to cause the *F*-layer over the equatorial region to support VHF propagation. The normal TEP signal path is between locations on each side of the equator. However, without the level of solar activity needed to keep the *F*-layer energized enough for VHF propagation, these paths don't materialize. The fall season of TEP usually tapers out by mid-November.This year, though, TEP will be rare, if it occurs at all.

Tropospheric-ducting propagation during this season is fairly non-existent, as the weather systems that spawn the inversions needed to create the duct are rare. On the other hand, using tropospheric-scatter-mode propagation is possible, but one needs to have very high-power, high-gain antenna systems. Having dual receivers in a voting configuration would also help. The idea is to use brute force to scatter RF off water droplets and other airborne particles and capture some of that signal at the far end with dual-diversity, high-gain receivers, which is not everyone's cup of tea.

Since we're at the very end of solar Cycle 23, and possibly at the start of Cycle 24, aurora is very unlikely. Even if there are periods when the solar wind speed is elevated and is magnetically oriented in a way to impact the geomagnetic field, this is the season when statistically we see very few aurora events.

The Solar Cycle Pulse

The observed sunspot numbers from July through September 2007 are 15.6, 9.9, and 4.8, respectively. The smoothed sunspot counts for January through March 2007 are 12.0, 11.6, and 10.8.

The monthly 10.7-cm (preliminary) numbers from July through September 2007 are 71.6, 69.2, and 67.1. The smoothed 10.7-cm radio flux numbers for January through March 2007 are 77.5, 76.9, and 76.0.

The smoothed planetary *A*-index (*Ap*) from January through March 2007 is all 8.4. The monthly readings from July through September 2007 are 8, 7, and 8.

The smoothed monthly sunspot numbers forecast for November 2007 through January 2008 are 20, 23, and 25, while the smoothed monthly 10.7-cm is predicted to be 77, 81, and 89 for the same period. Give or take about 12 points for all predictions. Notice that this indicates a rise that correlates with the start of solar Cycle 24. While predictions are for mid-2008 to be the official start of Cycle 24, the real figures and analysis indicates that Cycle 24 is under way.

(Note: These are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. I look forward to hearing from you. You are also welcome to share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>. Until the next issue, happy weak-signal DXing. 73, de Tomas, NW7US

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

When Will We Reach India?

When, one well may ask, will SETI succeed? We've been at this business for about a half century now, searching for radio evidence of our cosmic companions, and so far without success. Is this an open-ended enterprise, or is success in our sights?

At the SETI Institute, our friend and colleague Seth Shostak (you may know him as radio amateur N6UDK) has been grappling with this question, and he proposed an answer. In 2004, he submitted an article to the prestigious scientific journal *Acta Astronautica* entitled "When Will We Detect the Extraterrestrials?" Not one to shrink from controversy, Seth hung it all out there by proposing a definitive answer: within 20 years.

What led a respected scientist to take such a bold step, to go on record predicting SETI success within a single generation? Certainly, I'd never make such a prediction. (About a dozen years ago, I predicted 5,000 Project ARGUS stations would be online by the year 2000 ... and the actual number turned out to be just over a hundred.) No, I would have counseled caution, but Seth just had to go out there and make his numbers public. Did he pull his prediction out of a hat?

Hardly. What Dr. Shostak did, what we all do, is take the measure of the problem, state a set of assumptions, and attempt a plausible extrapolation from where we are now to where we need to arrive. Based upon his assumptions about the nature of ETI (which are just as valid as anyone else's), and his knowledge of technological trends (which is extensive, given his close involvement with the development of the Allen Telescope Array), he made a reasonable leap: At the rate our observational capacity is growing, if they're there and are like we think they are, we should have succeeded in detecting ETI by 2025.

You can quibble about the specific assumptions, but the methodology is sound. It reminds me of the prediction Christopher Columbus offered to Queen Isabella just as he was leaving port: "If our assumptions are correct, then I should reach India in sixty days."

Of course, Columbus never reached India. Instead, he bumped into a land mass the existence of which he had no reason to anticipate, no way to predict. Unwittingly, unknowingly, Columbus discovered the New World. Thus, I guess you'd have to call his quest a failure.

So too may the SETI enterprise end up a total failure. We may never pull that elusive radio beacon out of the aether. However, in trying, we are developing some incredible new technology, the very technology Seth considered in making his bold prediction. Also, no one can say what great new discoveries technology might enable, along the road to SETI success or failure.

At a recent International Astronautical Congress, Seth Shostak, N6UDK, sought to answer the question "When will we detect the extraterrestrials?" Seth chairs, and the author co-chairs, the SETI Permanent Study Group of the International Academy of Astronautics. (N6TX photo)

I find the title of Shostak's article especially interesting, because it underscores a paradigm shift that has occurred within his and my lifetime. In SETI science's formative days, the deeply held perception in scientific circles was that life on Earth is unique. Today, the overwhelming majority of experts envision a universe teeming with intelligent life, just waiting to be discovered. It is no wonder, then, that the article in question is entitled not "*Will* We Detect the Extraterrestrials?" but rather "*When?*" The existence of intelligent alien species is now accepted as a given. What remains to be determined is the *when* and the *where*. Seth Shostak has already made a guess as to the *when*, so I will now venture a prediction about *where*:

We won't find them in India, but rather in some previously unknown New World.

73, Paul, N6TX

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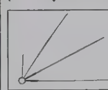

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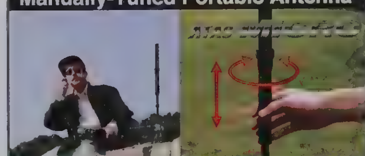

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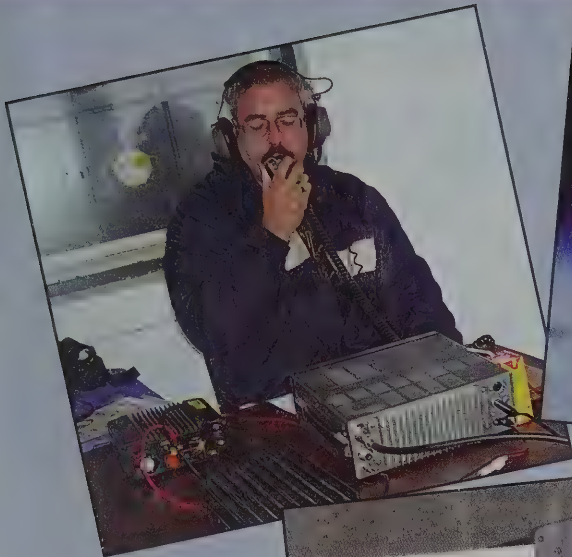

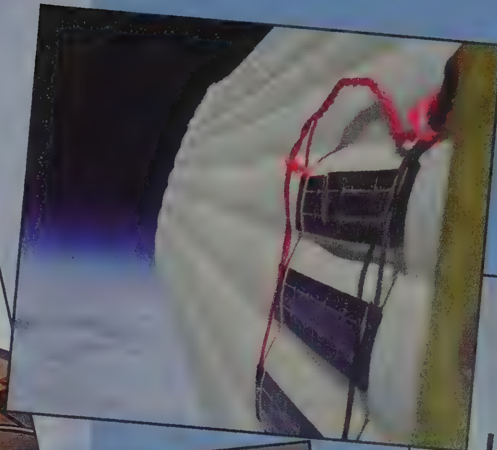

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DEPARTMENTS

On The Cover: BIG BLUE involves a unique project for the U.S. Space program's future Mars exploration (for details see p. 8); feature and photo by KG4YLM. Insets, left to right: "Up in the Air," column and photo by WB8ELK (see p. 71); "The BIG BLUE Project Flies On" sidebar, photo and text by Jamey Jacob (see p. 10); "Homing In," column and photo by KØOV (see p. 54).

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

On the Cover and What is Your Niche?

It's been five years in the making. It has involved dozens of students from two land-grant universities separated by 800 miles, the University of Kentucky (KY) and Oklahoma State University (OSU). It has involved NASA through its Space Grant Consortium and Workforce Development programs. It also has involved the Edge of Space Science (EOSS) organization. Today the result is a flexible-wing aircraft project called BIG BLUE.

The significance of of the name "BIG BLUE" is that while the University of Kentucky's official team name is the Wildcats, BIG BLUE is the university's unofficial nickname for its hugely successful basketball team. In the case of the flexible-wing aircraft project, BIG BLUE is the acronym for Baseline Inflatable-wing Glider Balloon-Launch Unmanned Experiment.

BIG BLUE is important in that the primary customer for the project, NASA, is considering using this aircraft for exploration on Mars. Eventual secondary customers may include any entity looking for an easily transportable and deployable drone.

What is significant regarding amateur radio is the number of students and faculty who have earned their amateur radio licenses while participating in the program. The program has either directly or indirectly produced nearly 50 new ham radio operators.

The program also has spun off a CubeSat project entitled "KySat." Several of the alumni of the BIG BLUE project are now at work developing an amateur satellite for future launch. You can begin reading this fascinating story on page 8 in this issue.

What is Your Niche?

Over the past several years the use of the VHF-plus frequencies has become more and more fragmented as growing technology has fostered an increasing number of niches. As a result, the long-term existing niches have declined accordingly.

In the past, these niches have included weak-signal, FM, satellite, ATV, and digital modes. They continue, but now within these niches technological advances have splintered some and encroached on others. For example, digital now includes HSMM, APRS, and D-STAR. FM now includes Echolink, IRLP, as well as D-STAR (on the repeater bands). Satellites now include balloon satellites and cube satellites. ATV, which previously almost exclusively operated from the ground, now has venues on balloons and in radio-controlled aircraft.

Weak-signal communications also has seen an increase in digital modes, thanks to the WSJT software development. An offshoot of that development is that EME communications has become divided between those who use it and those who refuse to use it. Furthermore, SSB meteor-scatter communications is all but non-existent.

All of this fractionalization isn't necessarily bad. The use of WSJT has opened EME communications to operators who previously had no way to communicate via that mode. Echolink, IRLP, and D-STAR have opened up worldwide communications via a mobile radio or a handheld. Furthermore, even though we have been at the bottom of the sunspot cycle, going into a new one, serious 6-meter operators continue to rack up country totals, again thanks to WSJT and the moon.

The World Wide Web also has played a role in all of these niches. In particular, it plays the role of a double-edged sword for weak-signal operators. On the one hand, in weak-signal many operators are spending more time on the computer rather than on the air. On the other hand, the use of the World Wide Web can alert some of these operators of an imminent band opening.

The web has also become a repository of every kind of idea and project that one can imagine building, as well as venues for operators to discuss their accomplishments and equipment in real time. Speaking of accomplishments, it used to be that we would send our reports to our favorite VHF column and wait for the reports to be published upwards of two months later. Not anymore. We post them to a listserv and the whole world sees them almost immediately, if not in real time. The fallout for us VHF-plus scribes is that fewer and fewer operators send reports to either me or Gene Zimmerman, W3ZZ, over at *QST*.

Speaking of real time, how many of us have watched DXpeditions under way via live streaming video? We can almost witness the DX station typing us into the log on the station's networked computer. Within a few minutes we can go to the DXpedition's website and see if we are "in the log" or if they have our callsign wrong.

All of this discussion about niches leads me to encourage you to go to Dayton this year for the annual Hamvention®. If you would like to find out more about each of the niches mentioned thus far in this editorial, as well as others, then I invite you to attend the forums that cater to your interests.

Friday forums include TAPR, D-STAR, balloons, and APRS. Saturday forums include ATV and VHF/UHF/microwave. Sunday forums include the Mars Desert Research Station and its use of amateur radio, as well as bicycle mobile. If banquets are your thing, then there is a group of weak-signal VHF operators gathering at the Red Lobster restaurant at 6500 Miller Lane on Thursday night, as well as many of the same group gathering at the Holiday Inn Dayton North at 2301 Wagoner Ford Road on Friday night for another banquet. If AMSAT and TAPR interests you, then they will hold their second joint banquet on Friday night at the Kohler Presidential Banquet Center in Kettering. More information and reservation information can be found on the AMSAT website: <http://www.amsat.org>.

Speaking of AMSAT, it will have a huge section in the same general area as last year's booths in the Hara Arena. There will be lots of activities, as well as opportunities for you to join or renew your membership with the organization.

When we think of Dayton, we naturally also think of the huge swap area. Among all of those outside spaces are goodies to pretty much cater to any of your particular interests. Even if you are transitioning from one niche to another, you can unload your old equipment and buy new equipment, as the case may be. After years of a downward trend, attendance is predicted to be higher this year. Therefore, you will have more buyers for your old stuff and more new stuff to view.

All of this discussion about niches brings me back to the second part of the title of this editorial: What is your niche? Whatever it may be, you will find lots of information about it at Dayton, as well as have the opportunity to meet new people who share your interests in the hobby.

I hope to see you there so that I can listen to your stories and ultimately encourage you to write them down so that I can publish them within this, your magazine. If you are not going to be at Dayton and you have a story to tell about your niche in the hobby, then please e-mail me at: <n6cl@sbcglobal.net>.

Until next time… 73 de Joe, N6CL

QUARTERLY CALENDAR OF EVENTS

Current Contests

ARRL June VHF QSO Party. The dates for this contest are 14–16. Complete rules are in the May issue of *QST*. Rules can also be found on the ARRL website (http://www.arrl. org). Many are making plans to activate rare grids. For the latest information on grid expeditions, check the VHF reflector (vhf@w6yx.stanford.edu) on the internet. For weeks in the run-up to the contest postings are made on the VHF reflector announcing rover operations and grid expeditions. It is a great opportunity for you to introduce the hobby to those who are not presently working the VHF-plus bands or who are not hams.

SMIRK Contest: The SMIRK 2008 QSO Party, sponsored by the Six Meter International Radio Klub, will be held from 0000 UTC June 21 until 2400 UTC June 22. This is a 6-meter-only contest. Exchange SMIRK number and grid square. Score 2 points per QSO with SMIRK members and 1 point per QSO with nonmembers. Multiply points times grid squares for final score. Awards are given for the top scorer in each ARRL section and country. Logs should be sent to: Dale Richardson, AA5XE, 214 Palo Verde Dr., Kerrville, TX 78028. Entries must be received by August 1. For more information go to: <http://www.smirk.org> and click on the SMIRK Contest link at the top of the page.

Field Day: ARRL's classic, Field Day, will be held on June 28–29. Complete rules for this contest can also be found in *QST* and at: <http://www.arrl.org>. In years past tremendous European openings have occurred on 6 meters. Also, as happened in 1998, large sporadic-*E* openings can occur. This is one of the best club-related events to involve new people in the hobby.

CQWW VHF Contest: This year's CQ WW VHF Contest will be held from 1800 UTC July 19 and 2100 UTC July 20. Rules for the contest can be found in the June issue of *CQ* magazine and at: <www.cq-amateur-radio.com>.

There are two important contests in August: The **ARRL UHF and Above Contest** is scheduled for August 2–3. The first weekend of the **ARRL 10 GHz** and above cumulative contest is scheduled for August 16–17. The second weekend is September 15–16. Complete rules for both contests can be found in the July issue of *QST* and on the ARRL's website listed above.

Current Conferences and Conventions

Dayton Hamvention®: This year's Hamvention® will be held as usual at the Hara Arena in Dayton, Ohio, May 16–18. For more information, go to: <http://www.hamvention.org>.

The annual **HamCom Hamfest** will be held June 13–14 in Plano, Texas. As always, the North Texas Microwave Society will present a microwave forum. For more info, see the HamCom website at <http://www.hamcom.org/>.

This year's **Central States VHF Society Conference** will be held in Wichita, Kansas, July 24–27, at the Wichita Airport Hilton. For more information, go to: <http://www.csvhfs.org/>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. The following have announced a call for papers for forthcoming events:

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

May 4	Good EME conditions
May 5	*Eta Aquarids* Meteor Shower Peak and New Moon
May 6	Moon Perigee
May 11	Very good EME conditions
May 12	First Quarter Moon
May 18	Poor EME conditions
May 20	Full Moon and Moon Apogee
May 25	Poor EME conditions
May 28	Last Quarter Moon
June 1	Good EME conditions
June 3	Moon Perigee and New Moon
June 8	Excellent EME conditions
June 10	First Quarter Moon
June 15	Poor EME conditions
June 16	Moon Apogee
June 18	Full Moon
June 21	Summer Solstice
June 22	Poor EME conditions
June 26	Last Quarter Moon
June 29	Moderate EME conditions
July 1	Moon Perigee
July 3	New Moon
July 6	Very good EME conditions
July 10	First Quarter Moon
July 13	Poor EME conditions
July 14	Moon Apogee
July 18	Full Moon
July 20	Poor EME conditions
July 25	Last Quarter Moon
July 27	Moderate EME conditions
July 28	*Southern Delta Aquarids* Meteor Shower Peak
July 29	Moon Perigee
Aug. 2	New Moon
Aug. 3	Very Good EME conditions
Aug. 8	First Quarter Moon
Aug. 10	Moon Apogee. Very poor EME conditions
Aug. 12	*Perseids* Meteor Shower Peak
Aug. 16	Full Moon
Aug. 17	Moderate EME conditions
Aug. 23	Last Quarter Moon
Aug. 24	Moderate EME conditions
Aug. 26	Moon Perigee
Aug. 31	New Moon; Good EME conditions

—EME conditions courtesy W5LUU.

Central States VHF Society Conference: Technical papers are solicited for the 42nd annual Central States VHF Society Conference to be held in Wichita, Kansas on July 24–27. Papers, presentations, and posters on all aspects of weak-signal VHF and above amateur radio are requested. You do not need to attend the conference, nor present your paper, to have it published in the *Proceedings.* Non-weak signal topics generally are not considered acceptable, but there may be exceptions. Contact the person below if you have any questions. Strong editorial preference will be given to those papers written and formatted specifically for publication, rather than as visual presentation aids. Submissions may be made via the following: electronic formats (preferred); via e-mail; uploaded to a website for subsequent downloading; on media (3.5" floppy, CD, USB stick/thumb drive). Deadline for submissions: for the *Proceedings,* June 2; for presentations to be delivered at the conference, June 30; for notifying them that you will have a poster to be displayed at the conference, June 30. Bring your poster with you on July 28. Contact info: Mel Graves, WRØI, e-mail: <wr0i@sgdrugfree.com>, or snail mail: P.O. Box 273, Wichita, KS 67201-0273.

ARI – Comitato Regionale Toscana is calling for the submission of papers and presentations for the upcoming 13th EME Conference to be held in Florence, Italy, Aug. 8–10. Material is solicited on the technical and operational aspects of EME. Deadline for submission of papers and presentations is May 15. All submissions should be in Microsoft Word (.doc), Adobe Acrobat (.pdf), or Power Point format. When submitting a paper or presentation, please indicate if you plan to attend the conference or if you are submitting for publication only. Papers and presentations will be published in bound *Proceedings.* Send all questions, comments, and suggestions via e-mail to <eme2008@ari-crt.it>. For more info: <http://www.ari-crt/EME2008>.

Technical papers are solicited for presentation at the **27th Annual ARRL and TAPR Digital Communications Conference** to be held September 26–28 in Chicago, Illinois and publication in the conference *Proceedings.* Presentation at the conference is not required for publication. Submission of papers is due by July 31. Submissions, questions regarding suitable topics, and guidelines: Maty Weinberg, KB1EIB, ARRL, 225 Main Street, Newington, CT 06111, or via the internet to <maty@arrl.org>. Also check <http://www.arrl.org>.

Meteor Showers

May minor showers include the following and their possible radio peaks: η-*Aquarids*, May 5, 1800 UTC; ε-*Arietids*, May 9, 2000 UTC; May *Arietids*, May 16, 0300 UTC; o-*Cetids*, May 20, 0100 UTC.

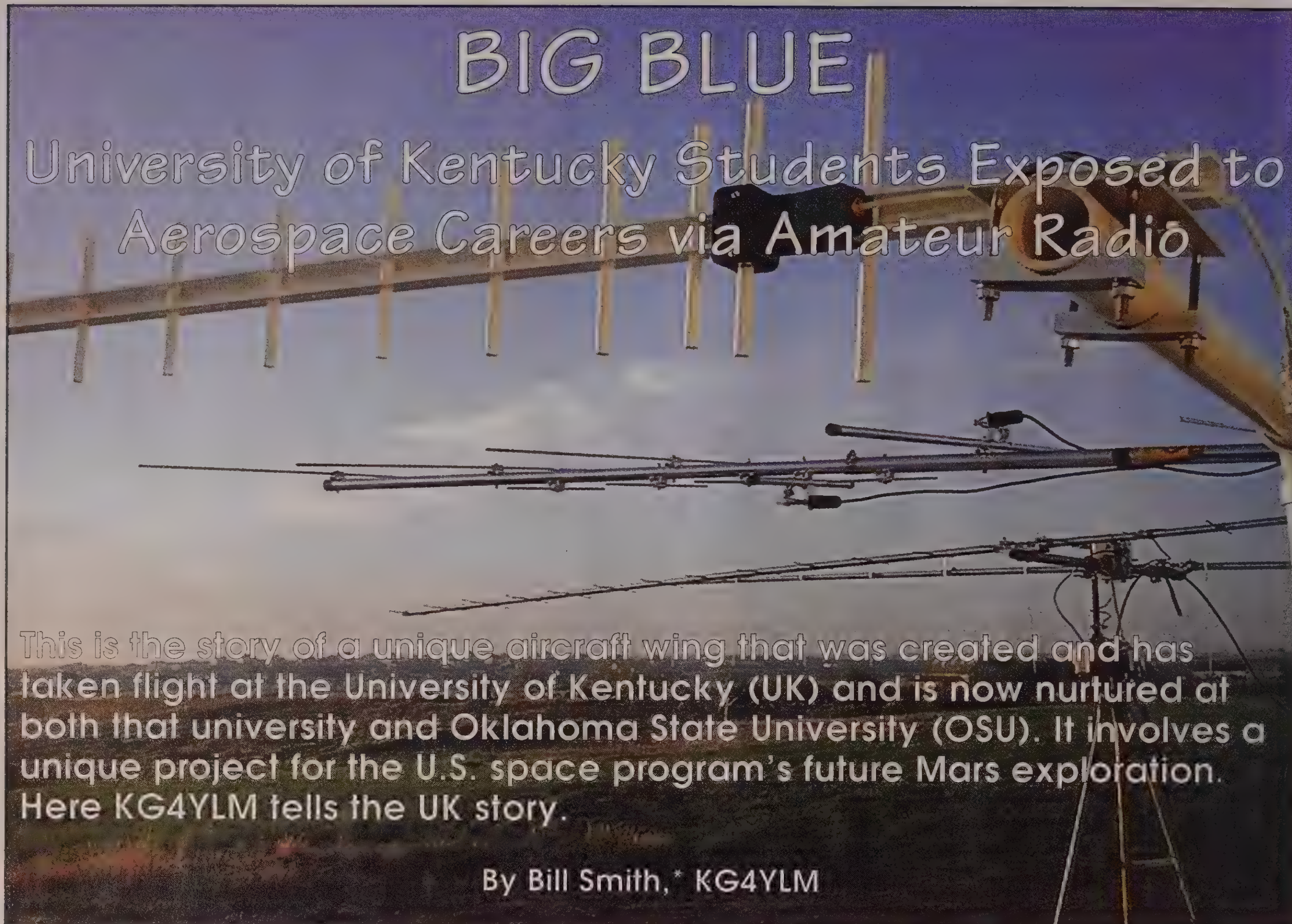
June: Between June 3 and 11, the *Arietids* meteor shower will take place. This is a daytime shower with the peak predicted to occur on June 7, at about 0500 UTC. Activity from this shower will be evident for around eight days, centered on the peak. At its peak, you can expect around 60 meteors per hour traveling at a velocity of around 37 km/sec (23 miles per second).

On June 9 the *Zeta Perseids* is expected to peak around 0400 UTC. At its maximum, it produces around 40 meteors per hour. The *Boötids* are expected to make a showing between June 27 and July 2, with a predicted peak on June 27, around 0230 UTC. On June 28 the *Beta Taurids* is expected to peak. Because it is a daytime shower, not much is known about the activity. However, according to the book *Meteors* by Neil Bone, this and the *Arietids* are two of the more active *radio* showers of the year. Peak activity for this one seems to favor a north-south path.

July: This month there are a number of minor showers. The *Piscis Austrinids* is expected to peak July 27. The δ-*Aquariids*, is a southern latitude shower. It has produced in excess of 20 meteors per hour in the past. Its predicted peak is around July 27. The α-*Capricornids* are expected to peak on July 29.

August: Beginning around July 17 and lasting until approximately August 24, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 1130–1400 UTC on August 12. A possible tertiary peak may occur around 1640 UTC. The κ-*Cygnids* meteor shower is expected to peak on August 17. The visually-impossible γ-*Leonids* is expected to peak August 25, around 0400 UTC. The α-*Aurigids* is expected to peak on August 31.

For details on the above meteor shower predictions see Tomas Hood, NW7US's Propagation column elsewhere in this issue. Also visit the International Meteor Organization's website: <http://www.imo.net/calendar/2008>.



BIG BLUE

University of Kentucky Students Exposed to Aerospace Careers via Amateur Radio

This is the story of a unique aircraft wing that was created and has taken flight at the University of Kentucky (UK) and is now nurtured at both that university and Oklahoma State University (OSU). It involves a unique project for the U.S. space program's future Mars exploration. Here KG4YLM tells the UK story.

By Bill Smith,* KG4YLM

Photo 1. The armada of packet and video Yagi antennas at the launch site of BIG BLUE 1. (All photos courtesy of the author)

Some of us faculty at the University of Kentucky (UK) had satisfying careers in the aerospace industry before entering academia and have continued with aerospace-related projects, primarily at the graduate level. UK does not, however, have an aerospace engineering program. Throughout the years, we have had students enter the aerospace industry despite the lack of a formal program. We needed a better tool to get our students exposed to projects in this vital scientific area.

Recognizing the future personnel needs of the aerospace profession, NASA initiated a Workforce Development program in 2002. One of the primary objectives was for the program student/participant to have a rich aerospace experience leading to increased interest in an aerospace career so as to maintain a strong workforce in the industry. This consideration is at the core of the University of Kentucky's NASA-supported project BIG BLUE. The project is inherently multi-disciplinary (like most *real* industry engineering projects), aimed primarily at undergraduates, and has led to an optional aerospace certificate earned along with a BS in Mechanical Engineering. A relatively high percentage of participating BIG BLUE students continue with aerospace-related careers or graduate studies.

BIG BLUE is an acronym for Baseline Inflatable-wing Glider Balloon-Launch Unmanned Experiment. It took the UK students a few days to come up with a title that is also the university's nickname.

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The BIG BLUE program began in 2002 with high-altitude ballooning and has spun off into other amateur radio related projects at UK involving UAV (unmanned autonomous airborne aircraft), amateur space nano-satellites, and rocket sub-orbital launches.

Most of this article deals with the UK BIG BLUE student experience with high-altitude balloon launches. It begins with an overview of the BIG BLUE genesis. Details of the platform and amateur radio communications required for our high-altitude balloon projects and hardware are described. The BIG BLUE follow-on projects at UK are then outlined. A summary of the student aerospace experience is also presented.

We started with a team of non-hams and came a long way relatively quickly through the support of some very experienced folks in the local amateur radio community (some of whom are mentioned below). Ham radio is a part of each of these projects. The projects included voice, data, and video signals on the 2-meter, 70-cm, 33-cm, and 13-cm bands. Important to most of these projects are small-size, low-weight, and low-power transceivers that work in a wide variety of temperature ranges and atmospheric pressures over relatively long ranges. These parameters presented the students with design challenges.

Overview of BIG BLUE

Suzanne Weaver Smith in Mechanical Engineering at UK is the overall project coordinator and advisor for BIG BLUE. In

addition to Suzanne, other advisors at the University of Kentucky were Jamey Jacob (mechanical engineering, now at Oklahoma State University), Jim Lumpp, KG4YLI (electrical and computer engineering), and Bill Smith, KG4YLM (also electrical and computer engineering).

Drs. Richard, N1ASA, and Karen Hackney, heads of the Kentucky Space Grant Consortium, attended a workshop in Colorado in 2002 that focused on high-altitude balloon experiments as an avenue for students to reach space. They suggested that UK provide an aerospace experience to students by proposing a high-altitude balloon project. Suzanne, Jamey, and colleagues at ILC, Dover, Inc. (known for, among other things, making NASA astronaut space suits and the Mars lander air bags) collaborated and proposed the following idea: Verify prototype technology for aeronautical exploration of Mars via high-altitude testing of an inflatable-winged glider platform. The inflatable wings are stowable, which is a requirement for space travel.

The first BIG BLUE mission (BB1) was to develop a platform to test the deployment of inflatable rigidizable wings co-developed by UK and ILC, Dover, Inc. The BBI wing material was impregnated with a curable resin that hardens upon exposure to UV light. This is advanta-

Photo 2. Launch of BIG BLUE 1 (payload with stowed wings at the bottom of the string).

Photo 3. BIG BLUE 1 payload tweaking by (near to far) Andy Martin, KG4YLR, Jim Lumpp, KG4YLI, and Osamah Rawashdeh, AI4DL.

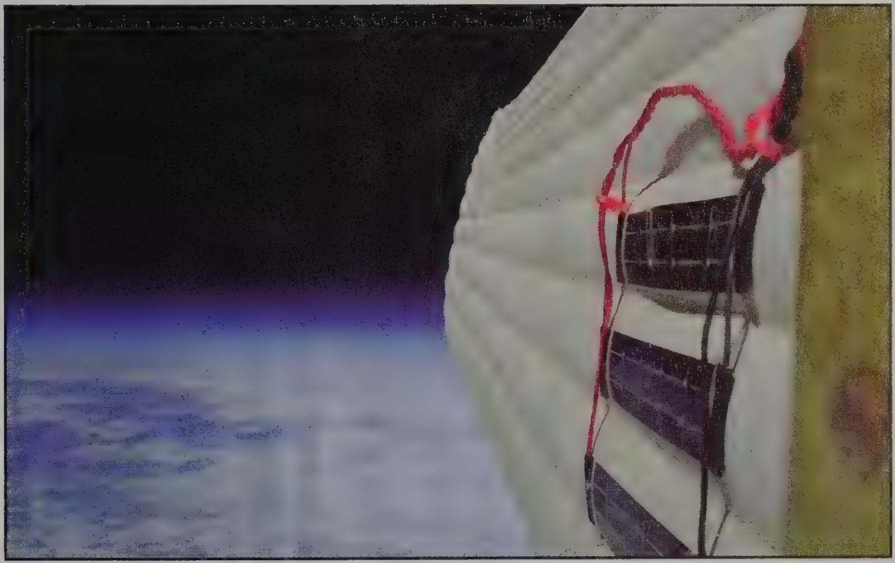

Photo 4. Snapshot of an inflatable wing and solar cells from the edge of space courtesy of BIG BLUE 3 (at approximately 95,000 ft. altitude). The money shot!

geous in that the wing pressure does not need to be maintained once it cures.

In order to verify our systems in a Mars-like atmosphere here on Earth, one needs to test at an altitude of around 100,000 feet. There is also sufficient UV radiation at that altitude (above all the clouds!). Through the Drs. Hackney, we were connected with launch service providers Edge of Space Sciences (http://www.eoss.org).

EOSS has been involved with many student projects over the years, some of which have previously been written about in *CQ VHF* magazine. It is an amateur radio non-profit group whose members promote educational activities through ham radio and high-altitude ballooning. Over the years, EOSS has developed very sophisticated tracking and recovery operation and they have a perfect record (126 successful flights/recoveries as of this writing). Tongue planted firmly in cheek, we often have said that EOSS is risking its "amateur status" given the very smooth and "professional-like" operation. It is this high reliability that sealed our partnership, as over the years the cost of our wing inflation platforms has been in the $15,000 range. We offer many thanks to now past-president Mike Manes, W5VSI, and his cohorts at EOSS who gave invaluable advice on what it takes to get to the edge of space and for getting us there and back.

Our first BIG BLUE project was scheduled for, start to finish, one semester. That included design, purchasing, constructing, testing, and launching of a fairly complex payload. The bad news is that we experienced engineers knew that one semester was not enough time to complete the project. The good news is that the inexperienced undergraduate students didn't know enough to realize that limitation and were able to successfully launch BB1 the weekend before spring semester final exams in 2003.

The sophistication of the project required that we be able to have two-way communications with the payload for command and control. The BB1 payload was housed in a glider fuselage around 6 feet in length with a deployed wingspan of about 6 feet (the wings were rolled up for stowing and deployed at high altitude). It weighed around 18 pounds. The inflation system consisted of a pressurized air-filled tank and a solenoidal valve that inflated the wings at a pre-planned altitude. The custom control electronics on board consisted of a micro-controller that

The BIG BLUE Project Flies On

With the hiring of Jamey Jacob by Oklahoma State University, the development of the BIG BLUE project continues, but now as a joint venture between Oklahoma State University and the University of Kentucky. The following sidebar brings the project up to date.

The University of Kentucky partnered with Oklahoma State University for BIG BLUE 5. While UK handled the inflatable-wing integration, sub-systems, autopilot, communication, and telemetry, students in OSU's Aerospace Engineering department designed and tested a custom fuselage around the wings and payload. This required that the teams of students separated by hundreds of miles collaborate on an evolving product design—much like what is done in the "real" aerospace industry.

The teams first met in Oklahoma in fall 2006 for a joint design meeting. Once the mission requirements were established, both teams began designing their respective systems, continually iterating their design based on feedback from the other teams. Both teams traveled to ILC, Dover, the wing manufacturer, in winter 2006 for a critical design review. Once the design was modified, flight testing was conducted in both in Oklahoma and Kentucky, which included testing of the autopilot and emergency recovery system. In spring 2007 the teams met in Kentucky for integration of the systems and wings with the final flight fuselage that flew to 89,000 feet in Colorado.

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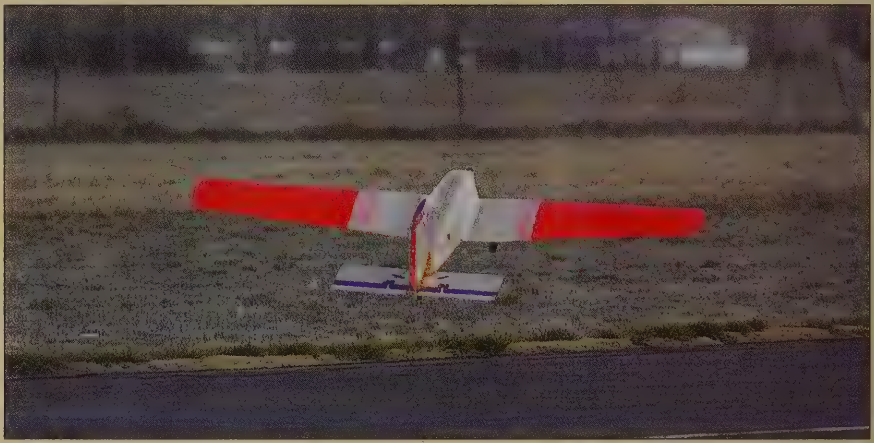

Aircraft prototype taking off for a test of flight worthiness and onboard systems.

Testing of the emergency parachute system to comply with FAA regulations.

was capable of throwing electronic switches (autonomously and via control signals from ground stations), monitoring temperature and pressure sensors, reading GPS data, and sending the data to the ground stations via packet communications and APRS. The switches were used to engage the inflation valve, cycle on and off an ATV transmitter for power conservation, and issue commands to take still pictures from a digital camera.

The control, sensor, and location data were transmitted via two Kenwood TH-D7s, one in packet mode and one in APRS mode transmitting approximately 0.5 watt each with omnidirectional rubber duckie antennas using 2-meter and 70-cm data bands. The ATV transmitter was a 1-watt AM transmitter built from a kit and used a homebrew dipole made from thin coax.

BB1 ground communications consisted of two nearly identical setups, one at the launch site and one mobile station located under the predicted flight apogee. These setups provided communication redundancy and gave us control coverage for almost the entire flight, from launch to touchdown (about 80 miles downrange and just under 90,000 ft. peak altitude). On the ground, we had a host of Yagi antennas for issuing commands and downlinking the signal. Using 1200-baud data has never been a problem for us, but we found there is an art to

Photo 5. AIRCAT flying with inflatable wing.

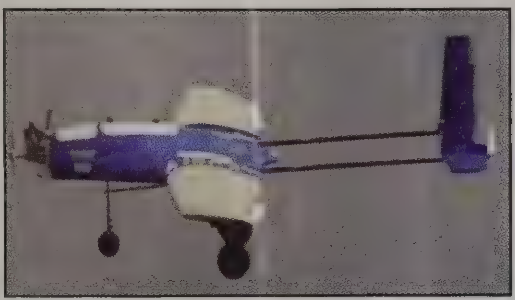

Photo 7. Alicia Mylin, KI4JAE, performing prelaunch wiring for BIG BLUE 5.

Photo 6. BIG BLUE 3, also known as the "Kentucky Fried Payload."

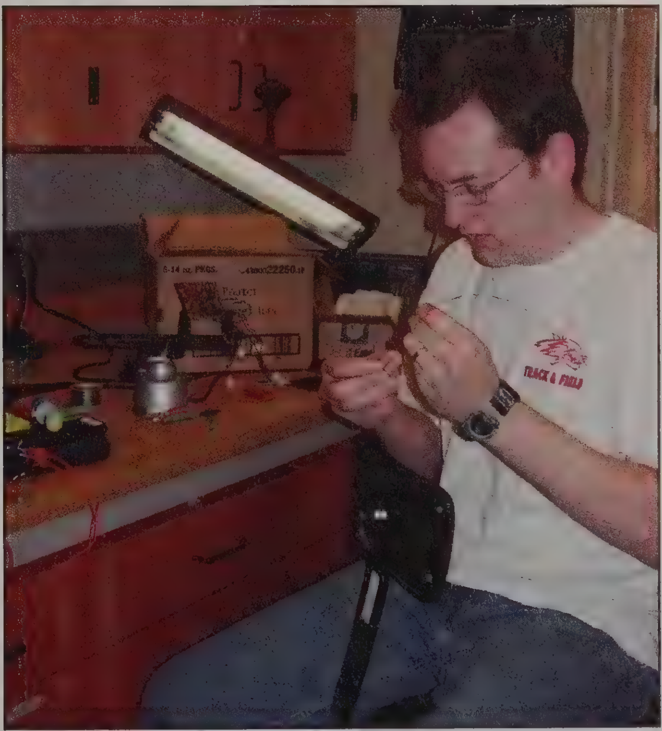

Photo 8. Robert Koontz, KI4JAH, tuning up the 33-cm ATV TX for BIG BLUE 3.

getting video to work well. In fact, it wasn't until BIG BLUE 3 that we successfully debugged all of our electronics and received live TV pictures of our wings inflating (we had previously relied on EOSS supplied video).

Other Ham Radio Supported Aerospace Projects

We are currently up to BIG BLUE 6. Some highlights from the prior BIG BLUE balloon launches include the following: BIG BLUE 2, spinning off aerospace experience to building custom UAV aircraft dubbed the AIRCAT (yes, that's also an acronym). BIG BLUE 3, balloon string payload draping over a 7-kV power line, frying an EOSS tracking beacon. That flight was affectionately named the "Kentucky Fried Payload." In BIG BLUE 5 (the final balloon-launched project—maybe?), we got permission from the FAA to cut our glider loose when the balloon payload returned within visual range. The bad news: We blew a wing off of the glider during inflation. The good news: We caught the destruction live with our amazing 13-cm

Mars Airplane Goals and Objectives

*By Jamey Jacob, PhD, PE**

The goal of the Mars Airplane project is to advance two objectives for NASA—one educational and the other technical. Both are focused on making flight on Mars a reality.

Educational Objective

The educational goals are to provide experience to undergraduate students in "NASA-like" projects to foster interest in aerospace careers. Mars aircraft development provides a multi-disciplinary systems engineering project grounded in aerospace engineering while helping NASA accomplish its scientific objectives. The Mars experience includes design, development, testing, flight, and data analysis of a complex aerospace prototype experiment to gain knowledge of multi-disciplinary team work and systems engineering, and a challenging, state-of-the-art experience including multiple contacts with NASA and industry researchers.

Since large-scale projects typically involve multiple companies and/or multiple locations requiring distance collaboration, this project simulates that environment by having students at Oklahoma State University (OSU) work with students at the University of Kentucky (UK, where the program originated under the direction of Profs. Jamey Jacob and William Smith) to complete the project. Each campus has ownership of (hence, responsibility for) portions of the project design and operation. Success requires teamwork across hundreds of miles. OSU is responsible for the design and flight testing of the aircraft and wings, while UK manages the avionics, integration, and launch services.

Technical Objective

Before flight on Mars can occur, many technical hurdles need to be overcome, not the least of which includes the development of a vehicle that can be packed into a small volume for re-entry into the Martian atmosphere and then deploy wings for flight in the low-density environment. Since the development and technical verification of an actual flight system would require millions of dollars and thousands of engineer-hours of effort, we are focusing on verifying one specific technology—inflatable wings. The goal is the development and testing of inflatable-wing technology to a TRL (Technology Readiness Level) of 7, which is verification in a relevant operational environment. This will be accomplished by testing the final design in the only environment on Earth that simulates the correct conditions on Mars—100,000 feet above sea level.

Questions about the Mars Airplane Project

Q: What is the purpose of this program?

A: First, it is a Mars aircraft technology demonstrator using a new kind of wing design developed with our industrial partner, ILC, Dover. Second, it is an undergraduate education project to introduce students to real-world engineering design projects and to prepare them for the 21st century high-tech work force, both in and outside of Oklahoma. We are currently funded by the Oklahoma Space Grant Consortium under the direction of Dr. Andy Arena. Our NASA partners include engineers at NASA Ames Research Center in California and NASA Langley Research Center in Virginia.

Q: Why is an aircraft needed for Mars and what does this technology do to address that?

A: We've explored only a small part of Mars. Orbiting satellites are too far away to get detailed information and rovers can't travel far enough to get a wide survey of information. Airplanes fill the void in between. However, an aircraft needs a very large wingspan to fly on Mars, yet must fit in a small space to be enclosed aboard the space craft to get from Earth to Mars. Thus, we need a way to fold the wings into a tightly packed volume. Our solution is to make these wings inflatable, like a balloon, except with a special design to keep the wings from buckling under aircraft loads with the wings being made of very strong materials, such as those used in bullet-proof jackets. Some of our earlier wings were made out of Vectran, which is the same material used in the air bags for the Mars landers, Spirit, and Opportunity. In fact, these wings were made of leftover material from those two sets of air bags, so we know that they are already Mars rated. Our latest designs use puncture-resistant polyurethane-coated rip-stop nylon that is specifically made for NASA space suits. So far, our combined student groups have tested the wing designs with numerous low-altitude flight tests and three high-altitude flights up to the edge of space, nearly 100,000 feet, to prove that this technology will work.

Q: What is unique about this project?

A: What we're doing is unique in several ways. This is the first time that this is being done anywhere. The type of technology that we're examining is cutting edge and may change the way aircraft, not just aircraft for Mars but all aircraft, are designed in the future. An inflatable/rigidizable version of this wing technology that hardens under exposure to UV light recently was featured in the Extreme Textiles Exhibit at the Smithsonian Cooper-Hewitt National Design Museum in New York City.

Q: How many students are involved?

A: Currently the project included approximately 15 students from the OSU School of Mechanical and Aerospace Engineering and 25 students from the University of Kentucky Department of Mechanical Engineering. The first high-altitude test flight was March 17, 2007.

Q: Where else can this technology be used?

A: Military applications are the most obvious, with the development of unmanned aerial vehicles that can fit in a soldier's backpack or be shot from a cannon. Applications are also being examined for Border Patrol, first responders, forest rangers, and flying cars. Unlike other unmanned aircraft, not only do these wings fit into small spaces when not in use, they are extremely durable and can survive almost any crash. They can also be morphed using wing warping techniques for flight control (such as used by the Wright Brothers on the Wright Flyer), similar to how a bird controls the way it flies.

For more information on the project, visit <http://marsairplane.okstate.edu>.

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wide-band FM video link from around 25+ miles range and still cut loose with descent under parachute. We've had successful student teams participating at the Pax River Student UAV competition in Maryland. A new, independent effort has begun under the umbrella of KySat (multi-Kentucky-university project supported and run through Kentucky Science and Technology Corporation, a private non-profit organization, <http://www.kysat.com>), where, among other things, development is under way to launch a CubeSat (4 inches on a side, less than 1 kg) orbiting with 2-meter and 70-cm amateur radios along with a 13-cm payload data radio.

Students Gain Rich Aerospace Experience

One of the main objectives of the BIG BLUE project is to deliver a realistic aerospace experience to our students. Over 300 students have been involved in the BIG BLUE projects, primarily undergraduates from mechanical engineering, electrical and computer engineering, computer science, and in BIG BLUE 5, some aerospace engineering students when we partnered with Oklahoma State. The students have been involved in all aspects of aircraft design, presented information at design reviews, with industry engineers and NASA scientists, that included aircraft construction, materials procurement, testing, integration, and flights of custom hardware with ham radio elements in the thick of things. We have had over 40 students (and two advisors) get their Technician Class licenses, with several going on to get their General and Amateur Extra tickets.

After five years, about 15% of the students entered the aerospace work force or went on for graduate degrees in aerospace-related disciplines. In that regard, BIG BLUE has been a great success for supporting a new generation of aerospace engineers. In any regard, BIG BLUE has brought a lot of attention to amateur radio at the University of Kentucky, and the projects involving amateur radio continue to grow in number.

Finally . . .

While this article gives you our story, we would also like to acknowledge great ham radio projects in related areas at other universities and schools that have been written about here in the pages of *CQ VHF* magazine.

We have a saying in our BIG BLUE program that we will accept help from anybody. We have to in order to get so much production from such a large student group with the relatively short time-lines for the projects. There is not enough room to list them all, but in addition to the above mentioned hams, BIG BLUE owes a great deal of gratitude to Bill Fuqua, WA4LAV, for his outstanding RF expertise. We also owe a big thank you to the Fattons of Windsor, Colorado, for unparalleled hospitality and unbelievable workshop support during our balloon-launch missions.

Building a 10-GHz FM Television Link

Since 2002, W3HMS has been designing and redesigning a microwave ATV system near his QTH in western Pennsylvania. Early on in his tinkering he realized a need for a reliable link between his two locations. Here he describes how he researched, developed, and established his 10-GHz link.

By John Jaminet,* W3HMS

In the Winter 2007 issue of *CQ VHF* in the article "Microwave TV, A New Approach!" I described the work we are doing here in central Pennsylvania using the 1280- and 3480-MHz bands. We have obtained very high-quality television pictures using FM for both the video carrier and the audio sub-carrier. Not very long after we went on the air with this system in 2002, the desire began to emerge to design and create a very high-quality linking system to cover a 17-mile path between two sites. The basic requirements for this system developed as follows:

• Super reliable 24/7—that is to say, never off the air (OK, almost never, hi!).

• The ability to withstand rain, snow, sleet, hail, heat, cold, and wind, all common in central Pennsylvania.

• The ability to send very high-quality FM video and FM audio sub-carrier signals (commercial quality) over this path with no apparent degradation of video or audio.

Our 24-inch offset dish and Bob Platt's Ku-band LNBF at the receiving end of a 17-mile path.

Receiving

This is the simplest part and uses a Bob Platts, G8OZP, [1] Ku-band LNBF with an LO of 9.0 GHz mounted on a 24-inch/60-cm offset dish made for satellite TV reception. This dish has a gain in the range of 31.5–33 dBd. The IF is 1400 MHz for an input of 10.400 GHz to a surplus analog "headend" cable-TV-system satellite receiver. In our case, we have used the Scientific-Atlanta 9660, Blonder-Tongue, Holland, and PICO receivers. We know that the IF is right to use U.S. analog satellite receivers as well. There are no doubt other equally fine receivers, and these are just the sub-set of our experience.

Of these receivers, the Scientific-Atlanta Model 9660 has given us the best audio and video signals due to the ability to adjust the audio de-emphasis to zero. This is an option not always present in satellite receivers. The others will work, but their audio quality will be reduced. The audio and video signals are taken from the satellite receiver for viewing and/or retransmission, recording, etc.

Transmission

This set of requirements started a search for what was available in the marketplace to meet our needs. We initially considered Gunnplexers, as Joe, WA3PTV, and I had exchanged full-color ATV pictures at 51 miles using about 250 mw at one end and 5–10 mw on the other end using 2-foot dishes. While the pictures were P5 (the best), we had no extra signal to combat fading or bad weather. We also had no 10-GHz audio, as we used 2 meters for the audio channel. We soon realized that both power and frequency stability above the Gunnplexer level were needed, plus an audio sub-carrier. That also suggested that using a Gunnplexer with a linear amplifier of 500 mw to 1 watt output was not viable due to cost and the drift problems inherent in Gunnplexers.

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Next we looked at the Kuhne Electronics ATV transmitters of 250 mw and 1 watt output, which use DRO oscillators and require a baseband video/audio unit for use on the air. Although I ordered the transmitter on a frequency of 10.400 GHz, it is adjustable ±50 MHz. The modulation is FM and the deviation can go to 10.75 MHz. The 1-watt model features a diode for monitoring the power output where 1 watt out equals 1.4 VDC.

As a weak-signal operator on all bands from 6 meters to 47 GHz, I use a considerable amount of equipment made by Kuhne and considered it the Cadillac of the business. It also comes with, alas, prices to match, particularly considering the much higher Euro-to-dollar rate of exchange since 2002. Nonetheless, I decided to order Kuhne's 1-watt transmitter and test the sub-carrier audio capability using a well-known commercial sub-carrier generator moved to 5.5 MHz. I say 5.5 MHz instead of the usual 4.5 MHz, as we planned to demodulate the signal with a satellite TV receiver. The test worked to a point, but the sound bars on the screen were intolerable, so that option was out.

After these tests we tried to get a baseband audio and video unit from a western European vendor, corresponding by phone calls and e-mail. This was an experience of supreme frustration and time wasted, for after some two to three months of lies, we learned that he had only one or two units available and no more units were going to be produced. Thus, we turned to the German firm ID-Elektronik, Inc., and after several e-mail exchanges we learned that this unit would indeed fulfill our needs. One unit was ordered by Gary, WA3CPO, our ATV project leader. The nomenclature is BBA2.4, and it cost $249.00 delivered in October 2006. We estimate the price today to be about $293 due to the dollar-to-Euro rate at US $1.466 to one Euro at the time of this writing.

This unit can accept microphone or line level audio input and has adjustment pots. The tech manual is in German, although the online Babelfish translator produced a copy that yielded good information, albeit grammatically very poor English! *One note of caution:* The shell of the power plug is *hot*—i.e., +12.6 VDC, which to me is not the normal amateur equipment expectation.

We decided to mount a Cincon 20-watt switching power supply sold by Mouser Electronics in the space vacated by the not-needed decoder in a Blonder-Tongue Model 6166 satellite receiver. This power supply outputs 15 VDC at 1.4 amps. We wanted +15 VDC to allow for cable loss and still have 12–15 VDC for the transmitter as specified by Kuhne. The cost was about $24. We mounted the BBA 2.4 in this satellite receiver with suitable jacks so we could patch received video and audio directly into the BBA or connect the BBA video and audio inputs to other sources.

The BBA 2.4 is also mounted in this space. There are only two RG-6 cables to the transmitter box—one for the 15 VDC and the other for the modulation output of the BBA, which contains both audio and video. The sub-carrier can be set in a frequency range from 5.5 to 7.5 MHz by grounding/leaving-open one or more of

three pins. We chose to use 6 MHz, as that is the stock frequency from the factory where no set pins are grounded. For a single point-to-point relay, any sub-carrier frequency is just fine as long as the satellite receiver can tune to the frequency.

We decided to build the unit in a diecast waterproof box to be mounted under the arm of a 2 -foot/60-cm satellite receiving dish to make the feedline very,very short. Losses at 10 GHz are huge with coaxial cable that is only fit for attenuators, and poor ones at that!

The feedline line thus is the small .141 semi-rigid cable. We selected a weatherproof box made by Markertek.com, catalog #KAB 3742. It is 7.5" × 4" × 2" and $21.95 each. We subsequently learned that the box can be much smaller, as only the transmitter is mounted in it plus some small components. The .141 cable is not flexible and should be bent *very carefully* by hand, all the while avoiding sharp bends. I often bend it around a medium-size screw driver so that any bends are circular and about like the curve in a US quarter coin.

Other components are a fuse after the power supply and an LED with series resistor on the panel, which is optional, as it just tells you the unit is powered on. Some might consider the fuse optional, but at the low cost involved I don't! The transmitter does not need a separate heat sink but must be mounted in a metal box for proper heat transfer. In our case, the box is mounted to a metal dish, which is itself mounted on a tower. Thus, *all* this metal is the heat sink.

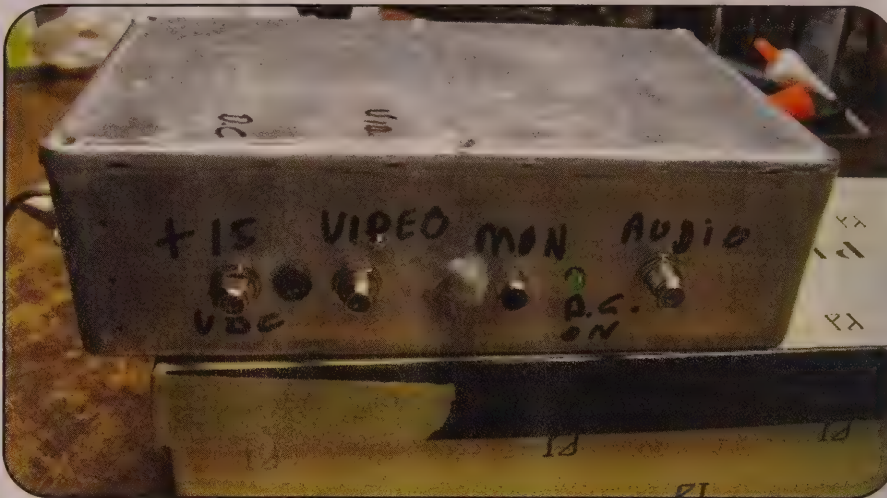
For the dish feed, we found that a satellite Ku-band LNBF made by DMS International, Model ASC 321 "Spitfire," sold for $9.00 (yes, nine dollars) could be converted to a feed by removing the two separate vertically and horizontally polarized LNBs and replacing the LNB probe in the same hole with a new probe that is 9.5 mm long. Cutting away the .141 shield requires a small hack saw or a commercial wire stripper.

This probe was made from a piece of .141 rigid cable with an SMA male connector at the end. If the probe is inserted into the bottom of the feed, it is vertically polarized; if it is inserted on the side, the polarization is horizontal. This aspect is actually not critical, because the feed can easily be rotated 90 degrees in its retaining ring to change polarization.

The option would have been to buy a transition for about $20 used (much more new) along with some brass sheeting, and design and build a feed using the plans of W1GHZ in his "Microwave Online Line Handbook" or his HDL.ant PC program. As I was curious about the gain and general effectiveness of this LNBF turned feed, I tested it alongside my W1GHZ dual-band 10- and 24-GHz feed and also on a 60-cm offset dish. The result: I could hardly tell the difference, yet my W1GHZ dual-band feed has made several 300-mile-plus 10-GHz QSOs on CW and even some SSB!

In installing the system, keep in mind that antenna pointing is *very precise* on 10 GHz, and the difference between P0 (just pix traces) and P5 (a snow-free picture) may be just a few degrees in pointing of either dish. You can calculate the pointing angle using free software by W1GHZ called HDL.ant available on his website…just Google on W1GHZ.

I emphasize again that pointing is very critical. Unlike the pointing of a 2-meter beam, where you have some signal long before it is at its strongest, you do not see the picture until it is just about at its strongest point. You may end up with a perfect picture but see *nothing* at all just a few degrees before your success.



The weatherproof diecast box that contains the DB6NT/Kuhne Electronics 1-watt, 10-GHz ATV transmitter.

A close-up view of the 24-inch offset dish and the LNBF shown here with the tower in the background.

The DB6NT/Kuhne Electronics 1-watt transmitter mounted in the diecast weatherproof box.

You will need to know your longitude and latitude or your 6-digit grid square from a GPS receiver or other source to input to the HDL.ant program. Then you can use a compass to get the bearing between sites, allowing for the variation, which in our area of central Pennsylvania is +11 degrees. This is to say that a true bearing of 90 degrees would be found with a compass reading of 101 degrees, which is called the magnetic bearing.

Results

To date, the Kuhne/DB6NT transmitter and BBA 2.4 combination has delivered perfect results with respect to reliability. Operating 24/7 with a 100% duty cycle, the units have logged more than 3000 hours of continuous operation since about September 10, 2007 without even one second of downtime; compare all the other equipment in your shack or your local 2-meter repeater with that performance level!

All transmissions have been in full color and sound at the commercial TV level. The transmitter does not seem to need a blower despite 100-plus days in hot weather, and low temperatures in the winter with rain, snow, sleet, hail, wind, and ice. The transmitter cost information is $351 delivered to Pennsylvania for the 250-mw model and $530 for the 1-watt model.

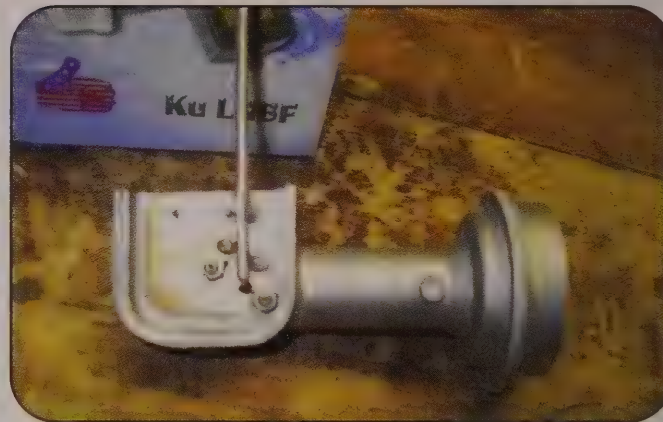
Future Improvements

No system is ever perfect, and ours is no exception. One known Achilles heel in the microwave ATV world is the radome over LNB/LNBFs, which tends to degrade thanks to the elements. I have had to replace at least two Dishnet LNBs over a 10-year period. I just recently found that the radome over my 10-GHz beacon had vanished. This was a plastic refrigerator bottle designed to hold cold water in cold temperatures. In its particular installation site, it is very possible that ice chunks melting and falling from a tall tower had come crashing down on the radome, breaking it into many small pieces. One solution used in Switzerland and perhaps elsewhere is to mount the offset dish upside down, thereby pointing the LNB down and not up. Gravity will cause water to flow out of the feed and not into it in the event the radome is cracked or absent.

Recent tests suggest we can use a slot antenna wrapped with Scotch™ #33 electrical tape shingle fashion (from the bottom up) and avoid radomes being subject to breakage. Even thick PVC seems not to be too lossy, but we have not tested that at a distance.

Cost Information

Resist the temptation to "do it on the cheap" as is sometimes



The Ku-band LNBF modified as described in the text to become an effective 10-GHz dish feed.

the mindset, which is often fine for short-term occasional-operation equipment. We know this transmit and receive system is expensive by ham standards, but it is also very, very dependable. The system cost recap is as follows; all prices are in US dollars, including shipping to the USA:

Transmitter 1 watt $530
BBA 2.4 (now BBA 2.5) $293
Satellite receiver $20
Equipment Box $24
Power supply $24
.141 cable $10
LNBF for feed $15
Platts LNBF $50
24 inch dish $30,quantity 2 = $60
RG-6 cable $20
Misc. connectors and small parts $10
Tower mounting $5
Total $1061

The 250-mw system cost is $882, and this may be sufficient power for some installations. Other hardware and miscellaneous items were donated and amounts not recorded.

In pricing, we have assumed the two systems will be tower mounted and have shown only a modest sum for these mounting costs. We know they can range from a few dollars when volunteers have much free hardware and time available, up to the "to the moon" price level if professional riggers are used and supply their own hardware. We also note that the "big ticket items" are sold in Euros and the Euro/dollar rate has been quite changeable in recent times, and not in our favor.

As you can see, when you enter the domain of the commercial operator with super-high reliability and performance standards, it is indeed a "whole new ball game" for hams. ■

Note

1. The Ku-band LNBF (low noise block receiving horns with integrated feeds) by Bob Platts, G8OZP, can be obtained from him via e-mail (g8ozp@btinternet.com) for 30 Pounds Sterling and payment by Paypal to that address. The price includes airmail shipment to the USA. Bob needs with your order: full name, callsign, e-mail address, residence and shipping address, and phone number, if no e-mail address. For this amateur band LNBF, Bob has replaced the normal 10.75-GHz LO (local oscillator) with one of 9 GHz and retuned the input filter for 10.0–10.5 GHz. Bob's telephone number when calling from the US is 011-44-12-8381-3392.

CQ's 6 Meter and Satellite WAZ Awards

(As of April 1, 2008)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23.24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	K0FF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3.6.10,18,19,23,27,29.32

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

*17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>

Get Ready for SuitSat-2

Among the many forums at this year's Dayton Hamvention® will be one given by AMSAT. A topic to be discussed is SuitSat-2. Here W5DID and K9JKM describe the tentative plans for this unique satellite contructed from a surplus Russian spacesuit.

By Louis McFadin,* W5DID, and JoAnne Maenpaa,† K9JKM

The science press called SuitSat-1/RadioSkaf-1 "the coolest and craziest project NASA ever made." The entire world—young and old, student and professional, amateur radio operator and SWL—was captivated by the image of the human form leaving the International Space Station (ISS) as the Expedition 12 crew of Bill McArthur, KC5ACR, and Valery Tokarev released SuitSat-1 into orbit.

Despite technical difficulties that allowed only the best-equipped stations to copy its signal, SuitSat-1 has provided to the international space agencies—including NASA, the European Space Agency (ESA), and the Russian Space Agency (RSA)—such a successful face on behalf of amateur radio that AMSAT, partnered with the Amateur Radio on the International Space Station (ARISS) project, may get another chance to not only repeat this feat, but now to include additional technical capability and student access to space never before available.

SuitSat-2/RadioSkaf-2 gives radio amateurs around the world the chance to participate in the exciting Amateur Radio in Space program. Here are some of the features of this new mission that we can look forward to:

- New SuitSat-2 satellite design building on the original SuitSat mission
- Expanded educational outreach program being developed
- Capability to support four student experimental packages
- 1200-baud AX25 packet digipeater
- CW beacon
- 400 bps PSK telemetry
- SSTV downlink
- FM voice messages
- Crossband U/V FM transponder
- Linear transponder based on software defined radio
- Solar power system to recharge suit batteries

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e-mail: <k9jkm@amsat.org>

Photo A. SuitSat-1/RadioSkaf-1 departs From the ISS. Thanks to the success of the first mission, this exciting event will happen again with a new SuitSat-2/RadioSkaf-2 currently in the development and testing stages by the Amateur Radio Aboard International Space Station (ARISS) and AMSAT teams.

New SuitSat-2 Satellite Design Gives More Capability

Given the short, three-month lead-time constraints when the SuitSat-1/Radioskaf-1 was approved, its basic electronics package consisted of a modified amateur radio FM transceiver to provide downlink-only capability of recorded greetings in several languages. Basic controls, battery-power system interface, and a helmet-mounted antenna were also developed and deployed.

SuitSat-2/Radioskaf-2 will support all the features of the first mission along with expanded capacity and an all-new electronics package. The primary mission objective remains to transmit educational and commemorative messages. A very important additional mission objective is that SuitSat-2/Radioskaf-2 will be the prototype test bed for testing new concepts in building future amateur radio satellites. Developmental and operational experience gained from these prototypes will be directly applicable to the upcoming AMSAT-DL P3E, AMSAT-

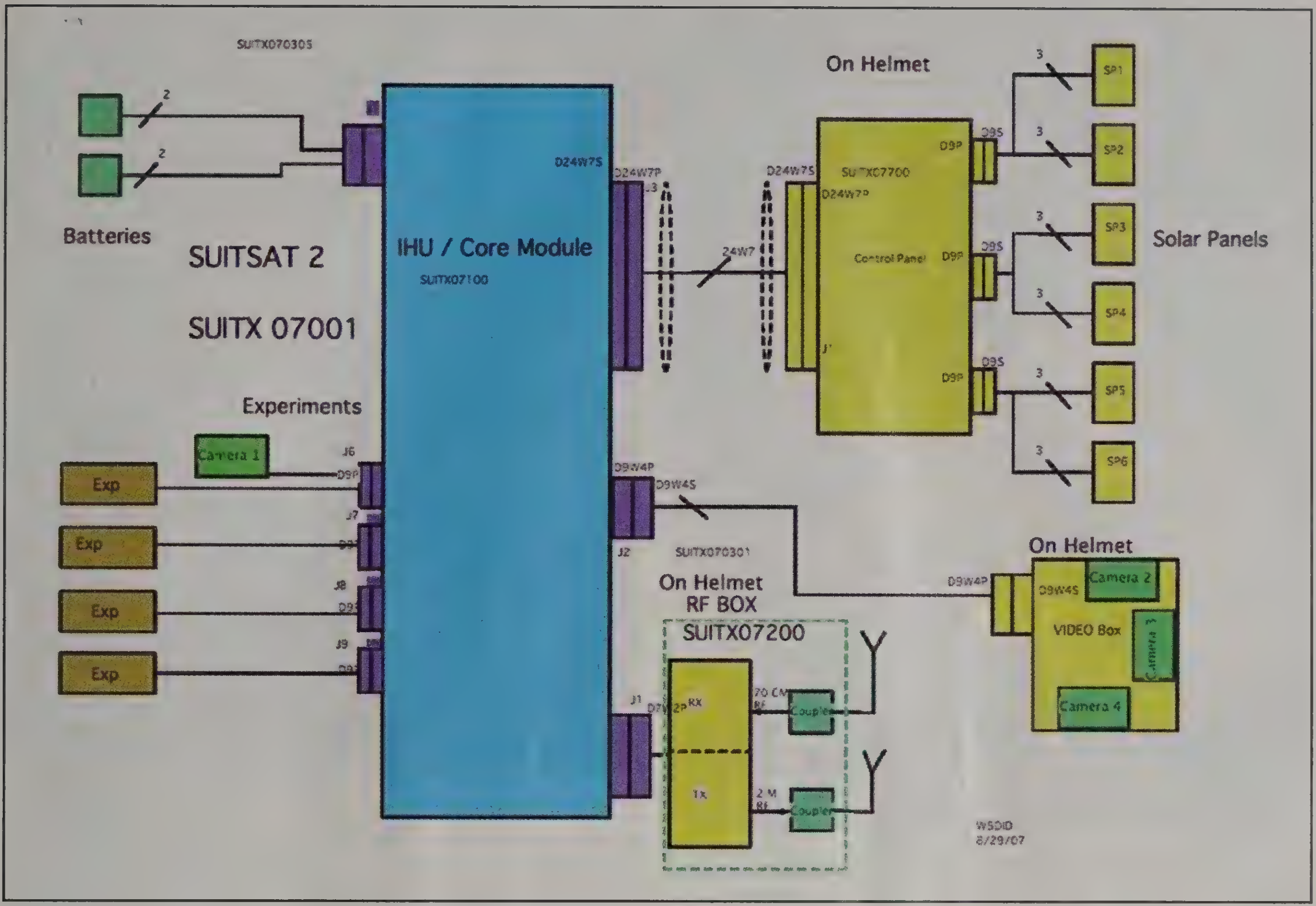

Figure 1. SuitSat-2 System Diagram. (Credit: Lou McFadin, W5DID)

UK/ESA SSETI, and AMSAT-NA Eagle high orbit and Phase IV/Intelsat geosynchronous missions.

The major modules of the SuitSat-2/Radioskaf-2 design, shown in figure 1, include the Internal Housekeeping Unit (IHU), power-control subsystem with batteries and solar panels, software-defined-radio transponder subsystem, interfaces for four CCD cameras, interfaces for four student experimental payloads, and helmet-mounted safety interlock, along with the helmet-mounted VHF and UHF antennas.

All of the space communications components are housed in a Russian Orlan Space Suit, which has reached the end of its service life. Rather than dumping it out with the trash, amateur radio operators have earned the opportunity to fill this suit with amateur radio gear. After it has been tossed overboard by the crew of the International Space Station, hams around the world will be able to communicate through this most unusual satellite. A unique mission such as this provides unprecedented scientific learning opportunities for students around the world.

Educational Outreach

If Amateur Radio in Space is to secure funding and consideration for future launch opportunities, we must continue to develop missions that excite our potential funding sources. The educational mission for students of all ages is one of the key elements radio amateurs can utilize to capture these opportunities.

SuitSat-1/Radioskaf-1 provided a unique opportunity to capture the imagination of students around the world. In a scene reminiscent of a science-fiction movie plot, the students' attention turned to the interesting prospect of tossing a trackable satellite overboard from the International Space Station, giving NASA, ARISS, ARRL, and AMSAT the chance to bring space-science education into the classroom along with an introduction of amateur radio to a new generation.

SuitSat-2/Radioskaf-2 expands student involvement when their participation expands from flying graphics and photographs on CD-ROM and downlinked voice messages to the development of the flight-package experiments. The student experiments will provide actual data from space directly back into their classroom. Amateur radio will once again provide the link from space to school.

The SuitSat-2/RadioSkaf-2 team has set up an educational group made up of Frank Bauer, KA3HDO; Rosalie White, K1STO; Rita Wright, KC9CDL; and staff from the Johnson Space Center Education Office, including Matt Keil, KE5ONH.

Rita Wright has completed lesson plans targeted for grades K–3, 4–6, and 7–12. These are being coordinated with the Johnson Space Center Education Office and the ARRL. They are planned initially to be deployed to NASA Explorer Schools, Aerospace Education Specialists, and the Science Engineering, Mathematics Aerospace Academies.

Photo B. Russian Orlan Space Suit will also be used for SuitSat-2/RadioSkaf-2. Note the helmet-mounted interlock/control box and antennas. SuitSat-2 will also be wearing CCD cameras on its helmet for SSTV transmission of photos back to Earth.

Photo C. The SuitSat-2 helmet-mounted flexible antenna shown in the stowed position. When the suit is deployed, the loop-and-hook strap is removed and the antenna elements will open to their operating configuration. Also shown is the helmet-mounted interlock control box the astronauts will use to turn on the SuitSat-2 payload.

Electrical Engineering students from The College of New Jersey, led by adjunct professors Bob McGwier, N4HY, and Frank Brickle, AB2KT, used their software-defined-radio class project to design and implement software and hardware for modulators and demodulators for SSB, FM, BPSK, and AFSK.

Experimental Packages

Four ports will be available for experimental packages. An interface specification document will be made available for developers. The suit power system will provide +5 VDC to each of the experimental payloads. The Internal Housekeeping Unit (IHU) computer will provide a signal at regular intervals to enable each experiment to download data. The ARISS team is working to select the schools that will fly experiments on SuitSat-2. GPS might be used in one experiment. Limitations include 5 watts, data rate, and short pass time of the suit so operators all over the world will be needed to help collect data from the experiments.

SuitSat-2/RadioSkaf-2 Operating Modes

CW Beacon

The CW ID will send SuitSat-2's station ID, experimental data, and a random ham operator's callsign. The list of random callsigns is being collected by ARISS representatives from each of the participating partners. This list will include the callsigns of amateur radio operators who have made a significant contribution to the Amateur Radio in Space Program, including manned and unmanned satellites. The entire list will be sent at random. There are plans for a contest to see who can copy the most callsigns.

400 bps PSK Telemetry

If you have a legacy AO-13 or AO-14 telemetry decoding system, you will be able to copy SuitSat-2's 400-bps PSK telemetry. SuitSat will send basic telemetry without error-correction bits to shorten the transmission sequence and to keep

Mode	% Power	CW	400 bps	FM Voice Message	Packet Digipeater	SSTV Photos	Linear Transponder
4	25	X	—	—	—	—	—
3	50	X	X	—	—	—	—
2	75	X	X	X	X	X	—
1	100	X	X	X	X	X	X

Table 1. SuitSat-2/RadioSkaf-2 operating modes. (Credit: Lou McFadin, W5DID)

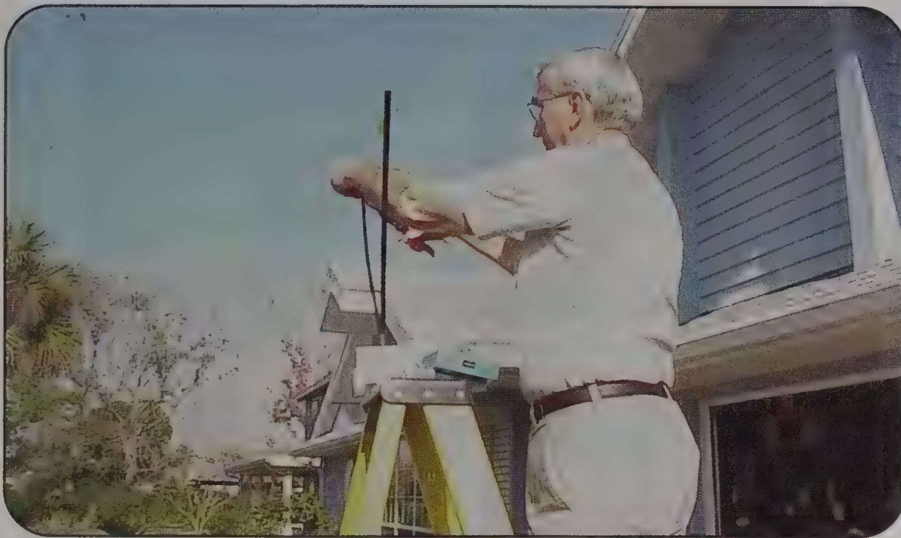

Photo D. Stan Wood, WA4NFY, testing the SuitSat-2 antenna on Earth.

it compatible with legacy systems many hams already have in the shack.

SSTV Downlink

SuitSat-2 will carry four cameras pointing in different directions mounted on the suit and helmet. The video system will examine the signal from each camera in sequence and capture a picture if there is anything in the field of view. When the SSTV mode is active, the picture will be sent on the FM voice downlink channel in the Robot 36 format.

There are several freeware and shareware SSTV programs for your shack PC. A little prelaunch research and experimentation on your part will have you ready to see what SuitSat-2 is seeing as it orbits over your QTH. If your station can successfully copy terrestrial SSTV signals, you will be ready for SSTV from space.

FM Voice Message

SuitSat-1 transmitted its voice message "This is SuitSat-1 RSØRS!" in several languages. This familiar voice beacon will be aboard SuitSat-2 to enable students and amateur radio operators, using common 2-meter ham

Getting Your Station Ready for SuitSat-2

While waiting for SuitSat's deployment, consider these opportunities to experiment and expand your ham station. It will be fun to learn more about new operating modes and get on the air on new bands!

• The one key station item for success in copying SuitSat-2 is your antenna. While you likely will not be able to copy its low-power signals (1 watt or less) with just your HT and a rubber duckie, you do not need to build an expensive tracking system either. An outdoor VHF antenna is definitely recommended to receive the 2-meter downlink from SuitSat-2. A small 3–5-element 2-meter beam is adequate for casual operating. Likewise, to utilize the UHF uplink you will need an outdoor beam for 437 MHz. Full azimuth-elevation tracking is not required. Many hams enjoy success by elevating the beams 20 degrees or so and using an inexpensive TV antenna rotor for the azimuth.

• Search the web for amateur radio packet software that will enable you to use your soundcard to transmit and receive the packet messages. If you get the software working with terrestrial signals first, you will have a good chance of success with signals from space.

• Search the web for amateur radio SSTV decoding software. If you get the software working with terrestrial signals first, you will have a good chance of success with signals from space.

• The legacy AO40RCV program may provide a starting point to copying the 400-bps PSK telemetry data. See <http://www.moetronix.com/ae4jy/ao40rcv.htm>.

• You can use your existing 2-meter and 70-cm FM transceivers for the FM signals. To take advantage of the linear transponder, you will need multimode capability on the VHF and UHF bands. Many modern rigs include HF through 6 meters to 2 meters and 70 cm. Also be on the lookout for transmit and receive converters to interface with your existing HF gear.

equipment many already have, to hear the suit.

Voice messages from around the world have been solicited from ARISS delegates to be included in the global greetings. The audio greetings are planned to come from Energia (Russia), ARISS Europe, ARISS Canada, ARISS U.S.A., and ARISS Japan.

Linear Transponder

The SuitSat-2/RadioSkaf-2 transmitter and receiver will be based on a software-defined-transponder (SDX) system being developed by AMSAT for the P3E, Eagle, and Phase IV-Geosynchronous satellites. The transponder system consists of an RF module and the digital signal processor (DSP) module. The receiver side of the RF module will contain a down-converter with 50 kHz bandwidth centered on 437.6125 MHz with an output to the DSP module at 10.7 MHz. The transmitter side of the RF module will contain an up-converter that receives the 10.7-MHz IF signal and converts it to a 145-MHz signal with 50-kHz bandwidth centered on 145.9375 MHz.

The DSP contains the hardware and software to demodulate and modulate the SSB, FM, BPSK, and AFSK signals in the passband. The CW ID, telemetry, audio, and packet signals will be injected at the DSP. The supported passband is shown in figure 2.

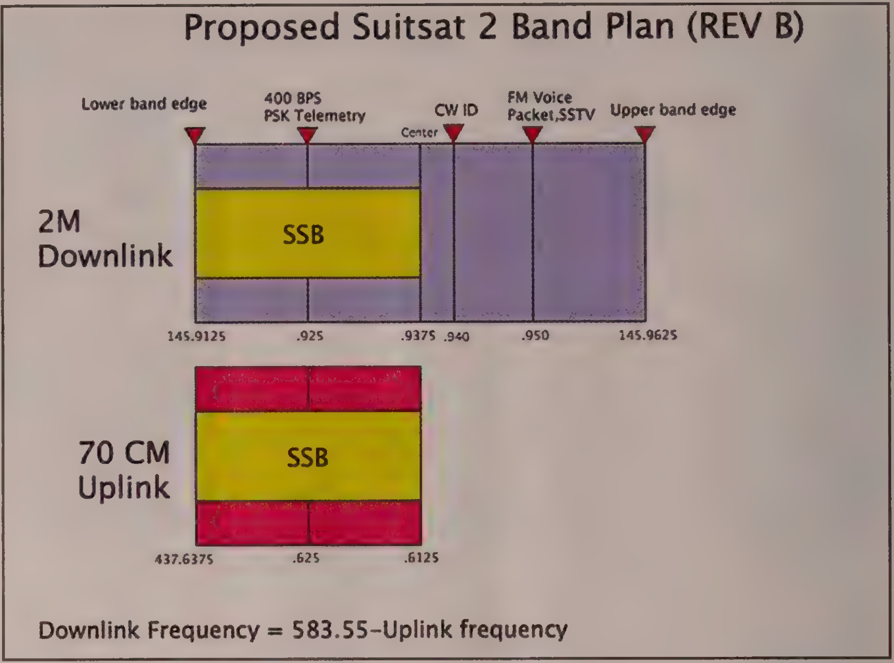

Figure 2. SuitSat-2 Band Plan. (Credit: Lou McFadin, W5DID)

Packet Digipeater

Radio amateurs will be able to enjoy occasional use of the 1200-baud AFSK packet digipeater when operating schedule and power budget allow. Packet operations, including APRS position reporting such as is supported on the ISS and PCSAT digipeaters, will enable hams to use equipment already available in their stations. There are several soundcard packet software packages if you do not own a packet TNC. A little prelaunch research and testing with terrestrial packet signals will have your station ready to receive packet from space.

Crossband U/V FM Transponder

Also, as the operating schedule and power budget allow, the crossband U/V FM transponder will let stations already equipped for operation on AO-51, SO-50, and AO-27 use this mode via SuitSat-2.

Solar Power System

NASA has made surplus solar panels available for ARISS. Originally developed for use on the NASA Small Explorer (SMEX) program, six of these panels will be strapped to the outside of the Orlan spacesuit. The panels will be oriented in different directions so that power is generated no matter which way the free-floating space suit is oriented.

Electrical power to the suit payload will be provided by the SuitSat-2 power subsystem as shown in figure 3. The SuitSat-2 team expects the payload to remain operational for six months or longer with the battery recharging provided by the solar cells on this mission.

About ARISS

Amateur Radio on the International Space Station is a volunteer program that

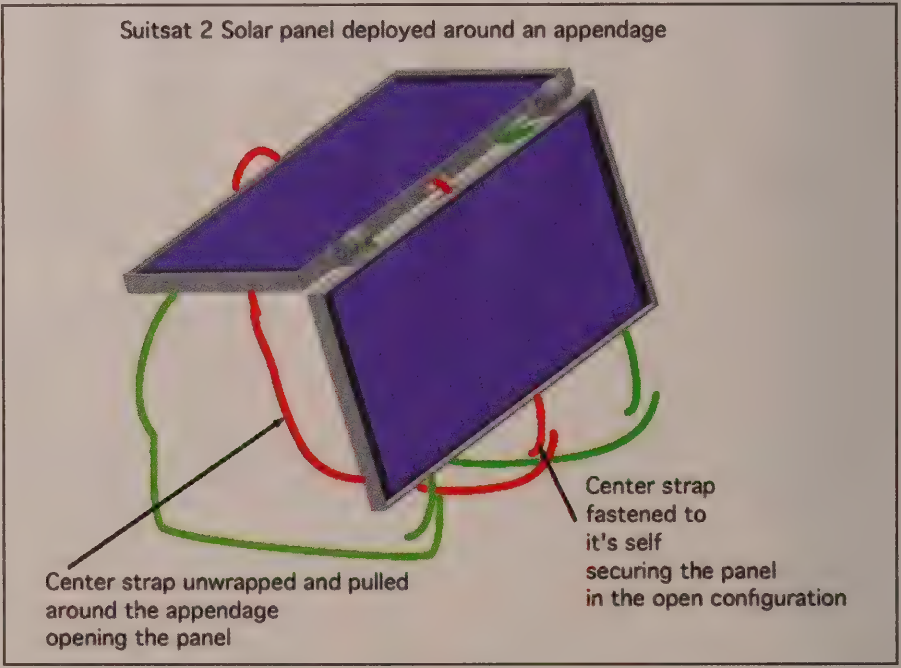

Figure 3. SuitSat-2 Solar Power System. The hinged solar cells can be attached to the Orlan Spacesuit's appendages with loop-and-hook straps. (Credit: Lou McFadin, W5DID)

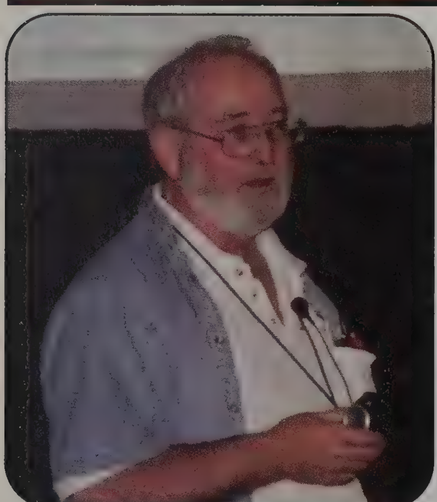

Photo E. Lou McFadin, W5DID, ARISS US Hardware Manager talks about the new capability of SuitSat-2 at the 2007 AMSAT Space Symposium.

References

"SuitSat-2/RadioSkaf-2: The Second Amateur Radio Space Suit Project and Stepping Stone to Future Small Amateur Satellites," Louis McFadin, W5DID, *Proceedings* of the 2007 AMSAT Space Symposium.

The following websites:

http://www.arrl.org/news/stories/2006/11/09/101/
http://www.arrl.org/news/stories/2007/01/24/101/?nc=1
http://www.dailygalaxy.com/my_weblog/2008/02/suitsat-one—th.html
http://www.rac.ca/ariss/
http://www.amsat.org/

inspires students worldwide to pursue careers in science, technology, engineering, and math through amateur radio communications opportunities with the ISS on-orbit crew.

ARISS is an international working group consisting of delegations from nine countries, including several countries in Europe, as well as Japan, Russia, Canada, and the USA. The organization is run by volunteers from the national amateur radio organizations and the international AMSAT (Radio Amateur Satellite Corporation) organizations from each country. Since ARISS is international in scope, the team coordinates locally with their respective space agency (e.g., ESA, NASA, JAXA, CSA, and the Russian Space Agency) and as an international team.

About AMSAT

AMSAT is a non-profit volunteer organization that designs, builds, and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions, and fellow amateur radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's vision is to deploy high Earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of low Earth orbit satellites developed in cooperation with the educational community and other amateur satellite groups. ■

AMSAT's New Spacecraft Integration Lab

Thanks to HISS and its affiliation with UMES, AMSAT's Spacecraft Integration Lab has a new location in Pocomoke City, Maryland. Here is the story of the new facility.

By Robert Davis,* KF4KSS, and J. C. Taylor,† W3JCT

In mid-2006, I (Bob, KF4KSS) asked my boss at the Hawk Institute for Space Sciences if he'd like to do anything with AMSAT. Much to my pleasure, he said, "Sure. What can we do?" Well, that response didn't fall on deaf ears!

The Hawk Institute for Space Sciences (HISS) is affiliated with the University of Maryland Eastern Shore (UMES). In the latter half of 2006, there were multiple phone calls and meetings between AMSAT and HISS, and between AMSAT and UMES. This resulted in several positive outcomes: AMSAT signed a Memorandum of Understanding separately with HISS and UMES, HISS offered free space for the AMSAT Spacecraft Integration Lab, AMSAT offered "seconds" of unused equipment to HISS, and UMES agreed to help AMSAT with education outreach.

By the holidays of 2006 I was in Orlando, Florida loading the contents of the famed AMSAT Orlando Spacecraft Integration Lab into rental trucks. The lab had been moved a couple of times (eventually into storage) after building damage from multiple hurricanes since its AO-40 heyday. Lou McFadin, W5DID, and Stan Wood, WA4NFY, brought us into the storage unit and helped sort and load the equipment into the trucks. Bob McGwier, N4HY, Drew Glasbrenner, KO4MA, and I drove the trucks back up the east coast to Pocomoke City, Maryland.

Waiting for us at HISS (to help unload trucks) were Rick Hambly, W2GPS; Rob Renoud, K3RWR; Brian Gaffney, K3PU; Paul Shuch, N6TX; Dan Schultz, N8FGV; and many more ham radio volunteers and some HISS heavy-lifters (and a forklift operator).

Since then, volunteers have spent a year working to make the new AMSAT Spacecraft Integration Lab in Pocomoke City, Maryland operational.

The biggest effort over the last year was the cleanroom. It came to us quite dirty and disassembled. After much cleaning, then sorting out the order of assembly, we brought in some forklift help and got to work. Before I gloss over any of the hard

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AMSAT lab equipment now in Pocomoke City, Maryland, as of January 2007. (All photos courtesy of Bob, KF4KSS, unless otherwise noted)

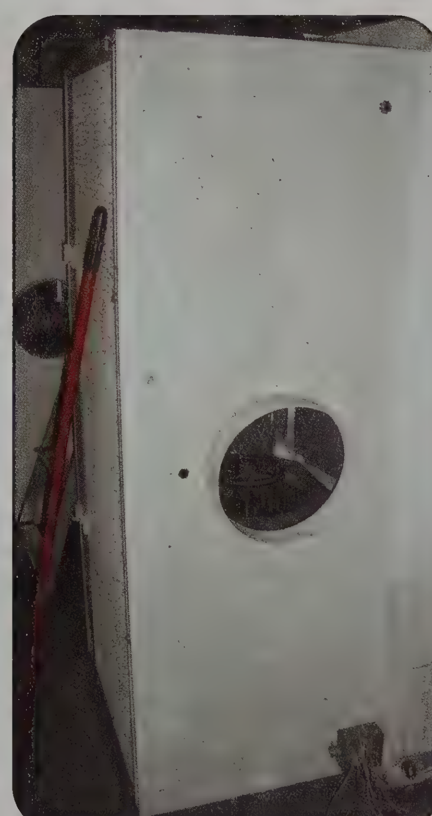
The cleanroom, section one of eight sections.

work of Saturday volunteers, I must reiterate that we cleaned … then stripped, scraped, sanded, welded, riveted, drilled, bolted, lifted, cleaned, primed, and finally painted the cleanroom. The emphasis is important!

As soon as the paint was dry (well, not dripping), we installed the $^{1}/_{4}$-inch thick, clear-plastic sheets that created the walls of the cleanroom. They are made out of special material that is static-dissipative, so it's safe to have around sensitive electronics. Then we installed HEPA filters in the ceiling. These filters are remarkably efficient and allow us to work on satellite parts with much less concern about contamination from typical sources such as dust (and us, as long as we wear the proper garments).

The cleanroom is now a gleaming 20

The cleanroom, section eight. Left to right: Ken Blake; Ray Fantini, KA3EKH; Caitlin Fantini; Bob Davis, KF4KSS; Claude Treherne; and Dick Daniels, W4PUJ. (Photo courtesy of J. C. Taylor, W3JCT)



An airhandler for the cleanroom.

The lab cleanroom, primed but not yet painted.

Cleanroom on the left.

feet by 20 feet with 8-foot ceilings. It's ready to support our spacecraft integration activities, such as prepping the SuitSat-2 solar panels, Eagle, and the potential rideshare opportunity with Intelsat.

Sitting next to the cleanroom is a flow bench. This can be used to work on small projects that should be clean but just aren't big enough to warrant entering the cleanroom. It is also used as a station to clean parts that will be passed into the cleanroom.

Behind the flow bench is an ante-room. This is where we "gown" for entry into the cleanroom.

Welcome to AMSAT Pocomoke

By J. C. Taylor, W3JCT

As a local ham and AMSAT volunteer, I would like to officially welcome AMSAT to Pocomoke and the greater area of the Delmarva Peninsula. This peninsula is nestled between the Chesapeake Bay and the Atlantic Ocean. Delmarva gets its name from the states of Delaware, Maryland, and Virginia. The peninsula is surrounded by metropolitan areas such as Philadelphia, Wilmington, Baltimore, Washington DC, Richmond, and Norfolk, yet the area is largely rural, agricultural, and maritime based. I think this peninsula has a lot in common with the spirit that we seek in AMSAT and the AMSAT laboratory.

I first met Bob, KF4KSS, after most of the AMSAT lab's worldly possessions arrived at the Pocomoke warehouse after a trip from Florida in early 2007. Equipment lay everywhere, and there was nothing here that looked like a lab to me, but Bob envisioned it all. Bob could see offices, laboratories, a cleanroom, and a machine shop. All I saw were large air-handling boxes that needed a lot of work. Test equipment and parts (some of which had names hard to pronounce) were everywhere. Just as the early settlers came from many walks of life, so did the volunteers. We washed, scrubbed, sanded, and painted with visions of satellites dancing in our heads. It has not been all work, thanks to Bob's dreams. At lunch we talked about the ground station, Eagle, the electronics, the construction, and satellites past and future. Last summer we even got to help at the STEP UP space camp at the University of Maryland Eastern Shore campus where a balloon project captivated young and old.

Now here we are a year later, and we see offices, a lab, a cleanroom, and a machine shop. The days of the cold warehouse, the scrubbing and painting, may be behind use, but they make us appreciate the time, money, and sacrifice of those who came before us in AMSAT.

Next to the cleanroom is the ground station. All the radios are lined up, but we haven't raised the tower with antennas yet. Talk about burning a hole in your pocket!

We also have a couple of benches where we can solder and work on electronics before they need to be maintained in the cleanroom. This hopefully will be a busy place later this year!

Where is all this located? The AMSAT Spacecraft Integration Lab is in the 8500-square-foot HISS facility in Pocomoke City. Pocomoke City is about 2 1/2 hours southeast of Washington, DC, but across the Bay Bridge on the DelMar, Virginia peninsula. We are conveniently located between the University of Maryland Eastern Shore (15 minutes north) and NASA Wallops Flight Facility (15 minutes south).

We are very anxious to get going on some projects now that the facilities are well in hand. AMSAT has plans for education outreach, SuitSat-2, the Eagle spacecraft, and the potential rideshare opportunity with Intelsat for a geostationary payload.

We have volunteers come in most Saturdays. If you're in the neighborhood and are interested in volunteering or donating, please e-mail me at <KF4KSS@amsat.org>. Everything that AMSAT does requires volunteers and gifts! Join us for the fun! Also, stay tuned to <http://www.amsat.org> for updates. ■

The ground station radios installed but the tower is not up yet.

Electronics benches.

The machine shop. It will never again be this pristine.

APRS Tactical Tropo Finder

Two new products this year are Kenwood's DM-710A and AvMap's G5 GPS receiver. WB6NOA writes about a unique use for these products in determining where tropospheric duct propagation might be occurring.

By Gordon West,* WB6NOA

When it's summertime, West Coast hams point their arrays to Hawaii. Like clockwork, July will be the "hot month" for the legendary tropospheric duct to open between Hawaii's Big Island and the west coast of the USA, a distance spanning 2500 miles.

"I am ready for the trip up the mountain, and the beacons are pounding out CW to the West Coast," comments Paul Lieb, KH6HME, the voice behind the big band openings on VHF and UHF in Hawaii. "Maybe this will be the year we complete on 10 GHz," says a smiling Lieb, hoping he and Chip Angle, N6CA, will be the first to span the California/Hawaii duct on X band. Lieb maintains beacons on the following frequencies: 144.170, 432.074.8, and 1296.340 MHz.

The importance of local weather conditions, at each end of the circuit, helps establish the correct altitude of the mainland duct termination. The duct may be at sea level or up as high as 700 feet, yet only be 100 feet thick. Many microwavers have become fascinated with all that APRS can do to spot fellow microwave positions when attempting to work the duct. For more information on APRS and the unattended Pete Brothers weather stations showing temperature and humidity please see: <http://www.aprs.net/vm/kpc3/remoteu2.htm>.

Kenwood's dual-band radios, tied into AvMap G5 bidirectional (and portable) GPS 5-inch color-screen mapping equipment, may offer the ultimate in "tracking the tropo," as well as others squawking APRS who may have found a tropo "hot spot." The AvMap G5 is a touch-screen, portable GPS receiver with a built-in (external available) 1.5-GHz receive antenna. The AvMap G5 offers cartography all the way down to dirt roads, covering all of the continental United States, Canada, Alaska, Hawaii, and Puerto Rico. It will speak driving directions, show you where the local Starbucks may be, and will go 100% portable in case you want to get out of the "rover" and scout out a walking-only high site.

The AvMap G5 has a 5-inch (diagonal) color screen and a series of five pushbuttons down the right edge of the device. the screen is clearly visible in all lighting conditions and responds well to presses on the "virtual" touch screen buttons. (Photos courtesy of the author)

As a bidirectional GPS, tied into the Kenwood D-7 handheld, or D-700 and D-710 mobiles, it will not only send out your GPS location to other operators, but also receive APRS position reports, including unattended station weather reports, and magically place them as "targets" on the GPS screen. If W6GPS calls you on the liaison frequency, indicating enormous signal strengths coming in from Hawaii, 2500 miles away, you will be able to see his position on your AvMap GPS mapping device and check out detailed weather information that also shows up on the face of the Kenwood!

Furthermore, if you have an internet connection, you can also check <http://www.aprs.fi> for detailed weather information—along with a whole lot of other information on APRS beacon stations.

"The new Kenwood D-710A has a much improved buffer for packet operations than the earlier D-700," comments Don Arnold, W6GPS, who is "Mr. Ham Tactical Navigator."

"The terminal node controller on the new 710A is now in the control head, not in the chassis, allowing for a shorter interface cable between the AvMap and the Kenwood head," adds Arnold. "I

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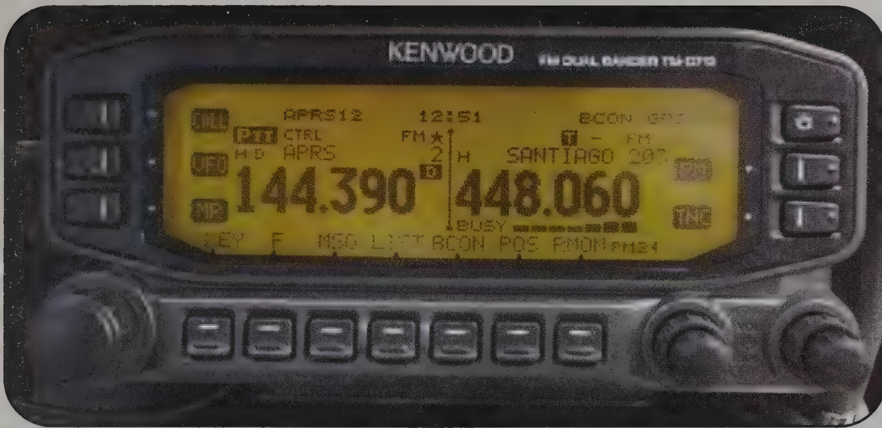

The AvMap G5 is being targeted directly at hams due to its advanced APRS features and close integration with the Kenwood D710A transceiver. Kenwood and AvMap worked together to make the G5 an ideal GPS system for APRS use.

switched out my Kenwood D-700 for the new Kenwood 710A and quickly saw the benefit of the new larger head and the twin radio capabilities of this larger readout," comments Julian Frost, N3JF. Frost points out there are actually two independent radios in the unit with two independent any-band readouts, where one can be dedicated to APRS 144.390 MHz, and the other to scanning and talking on the local 2-meter tropo liaison simplex frequency, including the capability for weather alert, for you storm chasers.

The actual tie-in between the Kenwood D-710A and the AvMap G5 is a simple bidirectional shielded cable, provided in the AvMap G5 box with full instructions for the interconnect. Don Arnold, working with Phil Parton of Kenwood and its Japanese engineers, helped develop the ham radio industry first "Tactical Navigation" to an APRS waypoint. See <http://youtube.com/w6gps> for a fun tour of tactical chasing!

Ham rocket launchers and balloon chasers will appreciate this new tactical mode for not needing to stare continuously at the screen for an update. With the new Kenwood D-710A and the AvMap G5, going "tactical" allows the user to set a specific callsign as a target and watch the information appear on the G5 screen. "Going 'tactical' is simple," claims Frost. You open a contact folder in the GPS, select the callsign of your intended target, and a small "T" will appear next to the callsign in the list.

When that target sends a new position report, the 710A uploads the new information from the AvMap GPS and processes all of the data coming down, creating a new Kenwood 710 data sentence specifically for following this target.

The AvMap tactical mode utilizes the G5's ability to receive APRS data from the Kenwood D710A transceiver. Normally when the transceiver receives an APRS packet, the position and station-type information is sent to the G5 and is displayed on the G5's screen.

In Tactical mode the user can display information about a specific station directly on the G5's screen in one, two, or all three of the G5's information boxes. To enable this feature, the user opens the "Where to go" screen by pressing the third button from the top in the row of buttons on the right edge of the G5, and selects the "Contacts" screen. After selecting the "APRS" folder, the user selects a moving station (moving stations have a red triangle icon next to their callsign) and is presented with several options, including the ability to view the station on the map, to plan a route to it, or to set it as a "Target."

When the user presses the "Set Target" button, the G5 records the position information on the target station and makes it available to the user. A target station is identified in the APRS folder by a small red "T" next to its callsign.

When the user goes back to the map, the G5 will display the target station's information on the screen. The user selects the information that is actually displayed by pressing one of the Information Boxes and selecting from Target ID, Lat/Lon, Speed, Course, or Altitude.

WB6NOA works tactical navigation from a police helicopter with the AvMap G5.

Like most GPS systems currently available, the G5 can store user Points of Interest (POI). The G5 can store each POI in a separate folder, and the user can create as many folders as needed and give each of them an appropriate name to differentiate one from another. The user-defined folders are stored in the Contacts folder. From the factory, the G5 comes with predefined Business, Personal, and Trip folders. When the G5 is connected to the Kenwood D710A transceiver in APRS mode, and the D710A receives the first APRS packet, the G5 creates an "APRS" folder and stores station information there. APRS station information is never deleted from this folder, unless the user deletes the folder at some point. The G5 automatically recreates the folder when the first APRS position packet is received.

"When an APRS station beacons the first time, you can see its position by its callsign on the screen with a blue circle. When it moves more than 100 meters, on the next reposition report it becomes a moving Target icon with a red triangle," comments Arnold.

"Now here's the good part: To keep track of this balloon target, or ham hang glider, or roving tropo station, simply tap the screen on the G5 to bring up Target fields, and watch the target latitude and longitude change, or track speed over ground and course over ground," adds Arnold.

It gets better! If you have been watching an APRS station tied into a Pete Brothers weather station, and you see a sharp increase in air temperature, you can look at the Kenwood to obtain full weather parameters and then check your AvMap for range, bearing, and driving instructions for quick navigation to that target. The Kenwood D710A, specifically set for this tactical mode, requires only four menu settings:

• Menu 600 Your callsign
• Menu 602 Baud rate at 9600 input GPS Output waypoint
• Menu 611 Auto
• TNC (on front panel) to APRS 12

On the AvMap, simply plug the supplied cable into the TNC port and verify in the setup menu 9600 APRS. APRS activity is stored in the APRS subfolder of the Contacts folder in the G5. For VHF and UHF "rovers," this on-screen tactical mode allows you to leave that big bulky laptop at home! Street map details down to dirt roads are likely more accurate and up to date on the G5 than what you may already have in your laptop for mountain roads in your vicinity.

The AvMap G5 offers extraordinary GPS sensitivity, thanks to the imbedded SiRF Star 3 chip set. This could allow you to pinpoint, within 15 feet, your position and calculate microwave X-band bearings to distant stations, as well as probable microwave bearings to Paul in Hawaii.

Is this probable? Since no one has worked 2500 miles from the mainland to Hawaii on X band, many microwave experts say the X-band path could actually be several degrees off from precise calculations. The 10-GHz dish at the Mauna Loa station may easily be panned, hoping that a signal coming in from 2500 miles will indeed allow for more precise dish pointing.

The tactical mode with the AvMap and Kenwood products will be a great way to quickly drive to the same location where the DX path has magically appeared.

Who knows? Maybe, thanks to these new tools from Kenwood and AvMap, this summer will be the record breaker. If so, you will read about it here in a future issue of *CQ VHF* magazine. ■

Don Arnold, W6GPS, working up tactical navigation on the G5.

Spreading the Good News About VHF!

FCC amateur radio licensee statistics tell the story of the continuing decline in the number of licensed hams. The question in many of our minds is how to reverse the trend. WB2AMU suggests some ways in which we can use VHF to tell our stories.

By Ken Neubeck,* WB2AMU

At this point in the first decade of the new millennium, the amateur radio hobby appears to be at a crossroads. Will the hobby continue to grow and remain relevant? While there has been a significant number of hams upgrading to higher class licenses recently, there has been little increase in the overall number of approximately 650,000 licensees in the United States. It would seem that there is a need to encourage newcomers to join the amateur radio ranks by showing them some of the great things about the hobby, while also improving the public's perception of ham radio operators.

The VHF aspect of the hobby plays a major role in creating excitement and interest. Indeed, it is almost like missionary work, spreading the word about the fun that can be had on the VHF bands. This includes talking to friends, giving talks at radio clubs and ham events, and writing articles on the subject.

Having participated in several different aspects of VHF operating over the past 15 years, I think that the following list represents some of the positive points of VHF that can be used to sell this aspect of the hobby to experienced hams and newcomers as well:

1. The shorter wavelengths associated with the VHF frequencies makes it easier to construct smaller antennas that have significant gain.
2. Because of the smaller antennas, it is easier to set up portable stations, including on hilltop locations.
3. The VHF bands have some very interesting propagation modes that add to the excitement of the bands.
4. The grid-square concept leads to making certain areas of the United States and the world interesting places from which to operate.

Indeed, after a period of years it is possible to become jaded by only working DX on the HF frequencies. HF operating often means trying to have a long enough antenna or a big antenna setup, along with a base station transceiver, etc. This can get pretty tough when you have limited available space. Additionally, HF band conditions are predictable with regard to what point we are at in the solar cycle, and there are not too many surprises. In contrast, VHF operating does bring surprises. There are many things VHF operators know that could easily infuse new life into the hobby by spreading the word. This article will explore some of the specific areas.

Photo 1. Setting up a 6-meter station for Field Day requires only a moderate amount of effort. Seen here is a three-element Yagi that is up 15 feet on mast sections overlooking Long Island Sound during a recent Field Day effort that was conducted by the Peconic ARC. This setup has worked very well for line-of-sight operation as well as major sporadic-E openings. (Photo by the author)

Field Day: Promoting VHF Activity

Field Day has always been thought of as a traditional approach to showing new hams what the hobby has to offer. In general, many clubs take advantage of the fact that a VHF sta-

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Photo 2. Here is WB2AMU on the porch of Horton's Point Lighthouse during a Lighthouse Weekend effort in August 2005. Again, the setup for 6 meters and other VHF bands is relatively easy. (Photo by Warren Melhado, WM2Z)

tion does not count in the number of transmitters. There are both good and bad aspects of using a weak-signal VHF station for Field Day to expose operators to the VHF bands.

The good part is that since Field Day takes place at the end of June, there is an excellent probability that there will be sporadic-*E* propagation on the 6-meter band sometime during the 24-hour operating period. When sporadic-*E* occurs on a seemingly dead band, it can cause excitement for new hams. Based on my 6-meter experiences over the past 14 years of participating with the Peconic ARC on eastern Long Island during Field Day, I think that there was only one time when sporadic-*E* did not appear during the contest period. 1998 and 1999 were two excellent years when sporadic-*E* accounted for hundreds of QSOs for our group during the Field Day weekend.

On the other hand, not paying attention to details can cause a bad VHF experience during Field Day. Sometimes the people who are assigned to set up the VHF station do not use sufficient radios and antennas to do the job. For example, I have run across Field Day stations that use Saturn 6 Halos for 6 meters. Now a Saturn 6 Halo is fine for mobile use, and was particularly so in the heyday of 6 meters in the 1960s, when horizontal polarization was important in the minds of many. However, this antenna has no gain at all and is certainly a less than optimal antenna for picking out weak signals, as well as making the station's signal stronger. A two- or three-element Yagi is a simple enough antenna to put up for Field Day, and the benefit in signal strength in both directions is well worth the additional effort, particularly for inexperienced operators.

What is sometimes worse than improper equipment is the fact that the person who is charge of setting up the VHF station has limited experience with the general protocol of the bands as well as limited knowledge of the best times to look for certain propagation conditions. For example, any moderately experienced VHF operator who is in charge of the station would know that 6-meter activity on SSB begins at 50.125 MHz and moves up from there, and that activity on 2 meters centers around 144.200. Unfortunately, in some cases VHF is relegated to second-class status, and an inexperienced operator may be placed in charge of the station. It becomes obvious when one finds operators tuning in the wrong part of the band looking for activity on 6 or 2 meters. Worse yet, inexperienced operators sometimes call CQ in the DX window of 6 meters (between 50.100 and 50.125 MHz) and cause problems. Much of this can be avoided if experienced VHF operators help out.

Similar to Field Day type operations are special event stations, which are conducted throughout the year in the U.S. and elsewhere. Special event stations should consider 6 meters as a possibility, and even some of the other VHF bands when such events take place during the summer months. Lighthouse Weekend is one such event in August in which I have participated with the Peconic ARC by getting on 6 meters and sometimes tapping into a sporadic-*E* opening. There are also many other community-type events in which hams participate, and 6 meters and other VHF bands should be given consideration, in addition to the HF bands.

As an aside, I also have set up portable VHF stations and antennas during my lunch break at work, drawing the attention of non-hams from both my job and also people who work in the surrounding industrial park. When I work a station on 6 meters via sporadic-*E*, non-hams find it interesting and perhaps a seed has been planted to join our ranks.

The Importance of VHF Contest Activity

The impact of VHF contesting is sometimes understated in comparison to HF contesting with regard to the impact of generating excitement in the hobby. On a worldwide basis, there is much greater participation in the HF-based contests.

Photo 3. This is the 2-meter, three-element Yagi that was used after a major snowfall during my QRP portable effort for the January 2005 ARRL VHF Sweepstakes. The January event draws a lot of participation. (Photo by the author)

Photo 4. My setup for a recent ARRL September VHF QSO Party, where I used a telescope tripod on the roof of my car for the 2-meter Yagi and an umbrella stand for mounting the 6-meter Yagi. The VHF bands easily lend themselves to portable operations. (Photo by the author)

However, VHF contest activity becomes very important when considering that several of the VHF bands are generally quiet for much of the year until contests occur. This is especially true of 222 and 432 MHz. When interesting propagation conditions appear during a VHF contest, whether it be sporadic-*E*, aurora, or tropo extensions, it adds to the overall excitement and uniqueness of the VHF bands. The challenge is to be there when such openings occur and take advantage of them!

It is especially interesting to note from a qualitative perspective rather than just numerical results the popularity of the various radio contests. Indeed, the full impact of this perspective can be gleaned from the soapbox comments that are posted on the *CQ* and ARRL websites and in *CQ* magazine. Not only are there comments, but many of the submissions include photos that show the setups (both home and portable) that were used by the VHF contest stations. In addition, there are comments that indicate that a particular VHF contest was the first such experience for a station. A typical new VHFer comment is one by KB3PLG, who posted the following for the September 2007 ARRL VHF QSO Party: "I made a few contacts, some in the DC area, nothing too impressive, but it got me started on VHF." In addition to newcomers' comments, there were several from VHFers doing a different mode of operating for the first time, whether it be roving or adding new bands to their efforts. This, my friends, is the definition of growth in the amateur radio hobby.

Table 1 shows the number of soapbox comments that were posted on the ARRL contest website for 2007. It can be seen that after Field Day, the January and June VHF events had more comments posted than most of the other ARRL contests, including those that are HF-bands based! Even on a percentage basis, the VHF contests plus other VHF-related events (UHF and EME) score about a 5- to 10-percent range of comments in relation to the total number of entries, and this shows the enthusiasm of VHF and UHF operators. This type of enthusiasm is contagious and can be used to fuel growth in the hobby on these frequencies.

This analysis shows the importance of taking the time to post a soapbox comment that summarizes your observations of conditions on the VHF bands, as well as giving details of your station setup, particularly if it is portable. Also, take a photo and post it with your comments. There are many people who read these soapbox comments, and this can only help spread the word about the activity on VHF.

I think that it is important for experienced VHF operators to look at all reasonable opportunities to bring in new people, particularly if a multi-operator effort is being staged. Often most of the bands are occupied by rather experienced operators, but some bands, such as 432 MHz, might be a good starting point for a new operator. Newcomers will gain experience by watching the other operators as well, both when there are good band openings and when there are weak conditions. New operators can see first-

2007 ARRL Contest	No. of Entries	No. of Soapbox Comments
ARRL RTTY Round-Up	1112	25
ARRL January VHF Sweepstakes	**778**	**54**
ARRL International DX Contest (CW)	2569	25
ARRL International DX Contest (Phone)	2161	40
ARRL June VHF QSO Party	**860**	**59**
ARRL Field Day	2333	204
IARU HF World Championships	3193	17
ARRL UHF Contest	166	14
ARRL 10 GHz and Up Contest	115	14
ARRL September VHF QSO Party	**562**	**34**
ARRL International EME Competition	170+	26
ARRL November Sweepstakes (CW)	1000+	28
ARRL November Sweepstakes (Phone)	1500+	43
ARRL 160 Meter Contest	1000+	14
ARRL 10 Meter Contest	1800+	47

Table 1. 2007 ARRL contest soapbox comments. Note: The 2006 ARRL June VHF QSO Party had 83 comments as a result of major sporadic-E openings that occurred!

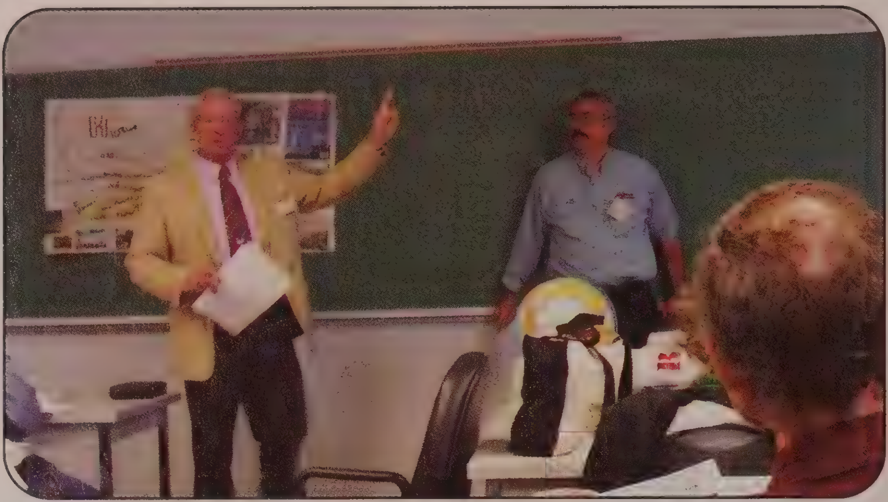

Photo 5. Here are Gordon West, WB6NOA, and Ken, WB2AM, and during their joint talk on VHF propagation at Ham Radio University in January 2006. This talk was about observations of the difference in VHF propagation modes experienced by operators on the east and west coasts of the U.S. (Photo by Ray Neubeck, W2ZUN)

hand the value of knowing CW when the latter situation occurs, as well.

One thing about operating during the CQ VHF Contest and ARRL VHF contests is that there are a limited number of stations that can be worked during the contest periods. Usually the QSO rate is highest during the first hour of the contest, when there are local stations to be worked, or when there is a major sporadic-*E* opening. Based on my experience, the first hour can yield a few dozen QSOs of the line-of-sight variety, or as was the case in June 2006, several dozen QSOs via sporadic-*E*. There are also slow periods during VHF contests, and believe it or not, this is a good thing at times because there is less operator fatigue overall, unlike some of the HF contests.

VHF Talks and Seminars

I have had the opportunity to talk about 6 meters and VHF propagation frequently over the past 15 years. I remember my first talk on 6 meters, which I gave back in September 1994 at the Candlewood Lake ARC in Brookfield, Connecticut. This was soon after my book *Six Meters, A Guide to The Magic Band* (Worldradio books) came out. I was invited to give this talk by a fellow 6-meter operator, Frank, N8WXQ, who was a member of the club. There were about 30 people in attendance, many of whom had no idea what operating on 6 meters was like. However, after I gave the talk, over the next few years there were more users of the 6-meter band in that area of Connecticut.

Since that time, I have averaged about two to four talks a year on either 6 meters or VHF propagation at either radio club meetings or ham radio conventions. One of my most favorable memories is a talk that I gave on 6 meters at the Boxboro, Massachusetts ham radio show in 2004. I had a room with over 70 people. On the other hand, I also gave a talk on 6 meters at a club meeting where there were just 10 people, but I was able to gain their interest, so attendance size is not a drawback.

For the past five years I have given a talk either on 6 meters or VHF propagation at Ham Radio University, an all-day event in January on Long island, New York, that provides dozens of forums on the hobby. As there are four forums going on simultaneously during any one-hour time slot, the typical attendance at each one can range from 20 to 30 people. It thus becomes important to give this talk each year in order to educate people who were at other talks during previous years, as well as newcomers.

I have found the style that works well for me is a bit of show-and-tell, along with providing some handouts. For a talk about getting started on 6 meters, I show some of the simple antenna designs that can be used on the band, such as a $^1/_4$-wave whip for mobile use, or for portable operations a two- or three-element beam. The same can be done for the other VHF bands, as well. The use of the antenna props help drive home the point of how easy it is to construct decent, small antennas for these bands.

I have a specific packet of handouts that I use when just talking about 6 meters. It includes the band plan, antenna designs, and some information on propagation. For VHF propagation talks, I have simple diagrams that illustrate how the different propagation modes work. I have found that it is very effective to give out these handouts rather than have attendees take notes.

Photo 6. When I give a talk on either VHF propagation or 6 meters, I arrive with plenty of props for show-and-tell. At Boxboro in 2006 a globe was used to explain some of the long-range propagation found on 6 meters, such as TEP (transequatorial propagation) and F2. On the front of the table, note the FT-690 with the quarter-wave whip attached. This was the portable setup that I used when I went to Bermuda in the summer of 1999. (Photo by Joe Nehm, W1JN)

In addition, I prefer not to use Power Point presentations for my talks, particularly when there are fewer than 20 people in attendance. In my experience, Power Point presentations make sense for the larger crowds, but not in smaller settings. I do, however, make use of audio tapes that demonstrate some of the unusual propagation modes found on VHF. The recordings of aurora-distorted signals that I have made during 6-meter aurora openings make a significant impression on those people who have never heard this before!

It is important for experienced VHF operators to promote VHF by giving talks at radio clubs and conventions. There is a big difference between the world of VHF and the world of HF. This year has already been a busy one for me in that regard, and I am looking forward to visiting a number of different states before the year is over.

Windows of Opportunity to Promote VHF

As VHF operators, it is imperative that we step up to the plate when opportunities arise regarding questions or events involving the VHF bands, particularly in the area of weak-signal operation. We must take advantage of these opportunities to educate others about VHF frequencies and promote growth on the bands.

Unfortunately, on occasion one of the things I have found with some veteran VHF operators is a closed mentality situation in which these people are happy with the way things are, and they do not want change or more activity. This is the "private trout pond" mentality. One can almost understand where they are coming from when looking at the major investment that they have made in equipment and antennas. However, there can be no growth in VHF or the hobby as a whole if that attitude is maintained.

Sure, it is great to have a big antenna setup and it is good for those who are fortunate enough to live in areas that allow this. However, the sad reality is that with the increase in areas that have cluster-style housing developments, the trend of antenna restrictions by both communities and local government is continuing. That is why it is important to keep promoting the point that a major aspect of VHF is the smaller wavelengths involved, which makes portable operations and modest home stations possible for those who cannot do otherwise. In other words, any reasonable effort to get on VHF should be encouraged.

I do know that sometimes veteran VHF operators get very upset when operators who are not knowledeable about 6 meters get on the air during Field Day and mess up the area around the DX window. This has caused issues in the past during some important 6-meter DXpeditions, too. This points out the importance of a Field Day group taking the time beforehand to make all of the operators aware of the protocol on 6 meters and the other VHF bands. Information about the 6-meter band plan should also be posted in the Field Day announcement.

The time to do this missionary-type work for the hobby is now, and we must find the right opportunities to encourage people to participate on the VHF bands. Think about promoting VHF among your friends, as well as giving an informative talk to your local radio club. Remind hams that many of their rigs have an entry point to the VHF bands with the inclusion of 6 meters on their new radios. ■

A Broad Look at 6m F2 Propagation for Cycle 24 and Beyond

Press releases in January told of the beginnings of solar Cycle 24. Now that it seems to have begun, the next question is what the cycle will look like over the next few years. K9LA gives some insight into what to expect for the new cycle.

By Carl Luetzelschwab,* K9LA

Earlier this year, on January 4, Sunspot Region 981 rotated into view. It was at 30°N solar latitude, and it was of the opposite magnetic polarity compared to previous Northern Hemisphere sunspots of Cycle 23. Since sunspots at the end of Cycle 23 occur near the solar equator, and since this new sunspot was at high latitude and of the opposite magnetic polarity, it turned out to be the long-awaited first sunspot of Cycle 24.

What does Cycle 24 hold in store for 6-meter *F2* propagation? From a prediction of the Cycle 24 magnitude, we can make a rough estimate of when to expect 6-meter *F2*. Unfortunately, there is no single consensus for the magnitude of Cycle 24. Of the many predictions in the scientific community (more than 30, and they range from very low to very high), the general consensus among scientists is that Cycle 24 will either be a larger than average cycle or a slightly smaller than average cycle. Figure 1 shows these two predictions from the Solar Cycle 24 Prediction Panel in terms of 10.7-cm solar flux, and adopted by the International Space Environment Service (from http://sec.noaa.gov/SolarCycle/). Note that the rate of ascent of Cycle 24 at the beginning of 2009 may give us an early indication of where Cycle 24 is headed.

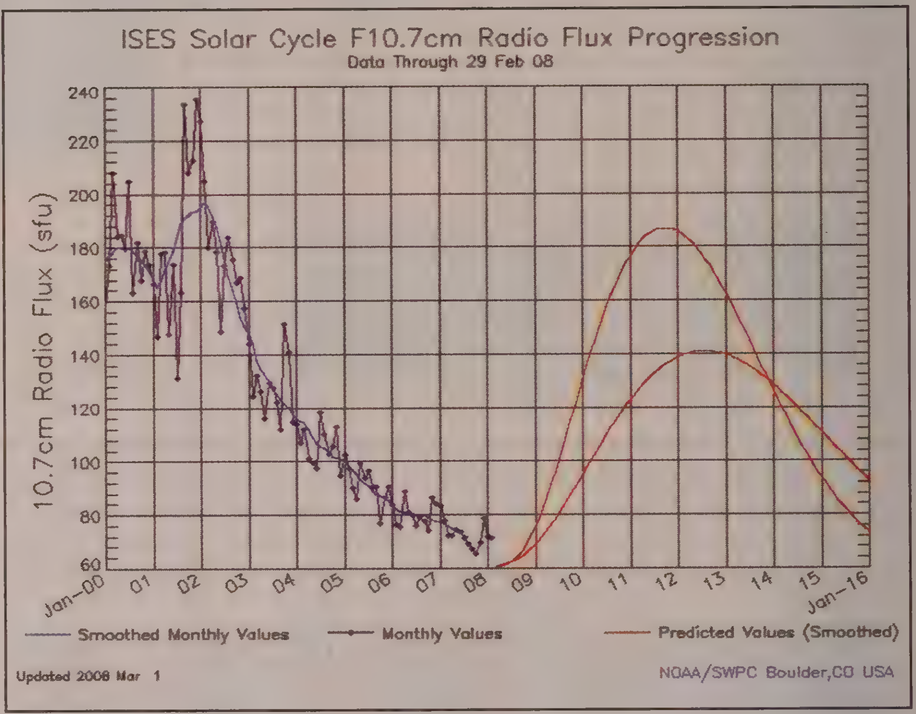

Figure 1. Predictions of Cycle 24 solar flux.

The prediction for the larger than average cycle says a maximum smoothed 10.7-cm solar flux of around 185 will occur in late 2011. The prediction for the slightly smaller than average cycle says a maximum smoothed 10.7-cm solar flux of around 140 will occur in mid-2012.

From probabilities of 6-meter *F2* propagation versus 10.7-cm solar flux (Emil Pocock, W3EP, "Predicting Transatlantic 50-MHz F-Layer Propagation," *QST*, March 1993), we can estimate when we're likely to see 6-meter *F2* propagation during Cycle 24. The W3EP data indicates the first signs (low probability) of 6-meter *F2* propagation may occur when the 10.7-cm solar flux is around 140, and 6-meter *F2* propagation increases to a probability of 50% when the 10.7-cm solar flux is around 220. It should be noted that these flux values need to be concurrent with a fall, winter, or spring month for those of us in the Northern Hemisphere, as these months result in the highest daytime maximum usable frequencies.

However, we can't directly apply the above solar-flux limits to the Cycle 24 data in figure 1, as the W3EP data is based on short-term solar flux, while the Cycle 24 data in figure 1 is smoothed solar flux. What we can do is note from the peak and decline of Cycle 23 in figure 1 that the short-term solar flux bounces around the smoothed solar flux, and the short-term solar flux will be, on average, about 15% higher at times than the smoothed solar flux. This observation allows us to translate the W3EP solar-flux limits to smoothed solar-flux values. For example, the 140 limit from W3EP says we need a smoothed solar flux of around 120 to have the short-term solar flux hit 140 at times. Now we can get back to estimating when we're likely to see 6-meter *F2* propagation during Cycle 24.

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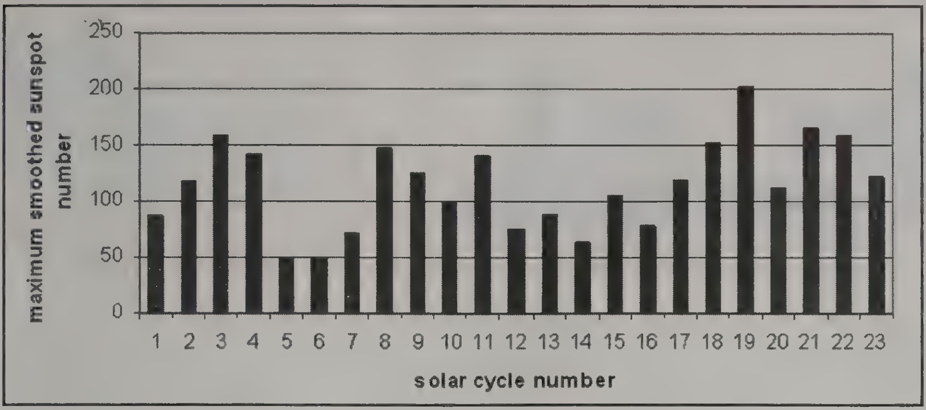

Figure 2. Maximum smoothed sunspot number of all 23 cycles.

If the larger than average prediction turns out to be what the sun does, then 6-meter *F2* propagation may start as early as late 2009. The highest probability will be around late 2011. After the peak, 6-meter *F2* propagation will likely drop out in early 2014.

In a like manner, if the slightly smaller than average prediction turns out to be what the sun does, then 6-meter *F2* propagation may start to occur in late 2010 and last until early 2014.

Note that these estimates are for a solar cycle with only one peak. If Cycle 24 does what Cycle 23 did (double peak), then we may have the opportunity for more 6-meter *F2* propagation.

Regardless of what happens, though, eventually Cycle 24 will come to an end. Then, of course, we'll wonder about 6-meter *F2* propagation for Cycle 25. Is there any indication of what Cycle 25 and beyond has in store for us? Yes, there is. We'll start by looking at the maximum smoothed sunspot number for all 23 solar cycles (see figure 2).

Note the cyclic nature of the data in figure 2. The data shows three long-duration periods (several solar cycles) of high solar activity. We have lived through the highest of these three high solar activity periods, which has been good for 6-meter *F2* propagation.

The data also shows two long-duration periods (again, several solar cycles) of low solar activity. The long-duration period comprised of Cycles 5, 6, and 7 is known as the Dalton Minimum. The data strongly suggests that we are on the verge of entering another long-duration period of low solar activity. Thus, Cycle 25 and a couple more after that may be low, with 6-meter *F2* propagation unlikely.

Is there any historical data confirming long-duration periods of low solar activity? Again, yes, there is; all we need to do is look at cosmogenic nuclides such as 14C (carbon-14) data in tree rings or 10Be (beryllium-10) data in ice cores. Both of these can be proxies for solar activity, since sunspot data is generally lacking. When solar activity is low, 14C and 10Be are generally high. When solar activity is high, 14C and 10Be are generally low. Figure 3 shows 14C data back to 800 AD (from Miyahara, et al, "Variation of solar cyclicity during the Spoerer Minimum," *Journal of Geophysical Research,* Volume 111, A03103, March 2006).

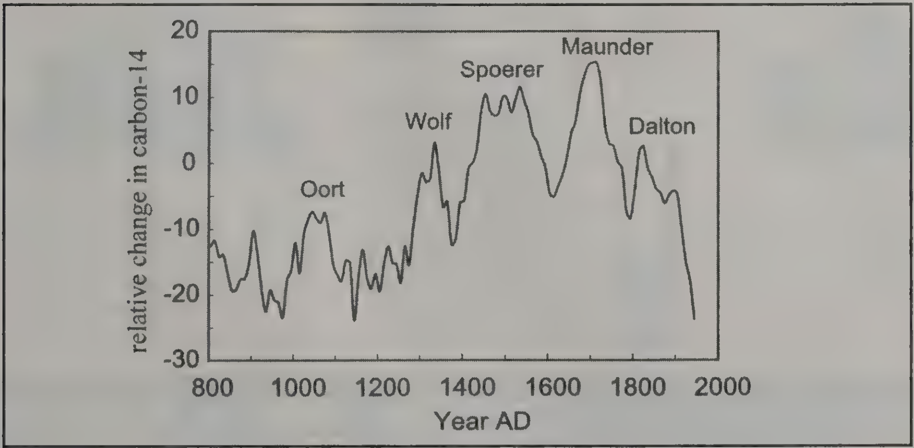

Figure 3. Carbon-14 data back to 800 AD.

Figure 3 shows the Dalton Minimum referenced earlier in Figure 2. Figure 3 also includes the Maunder Minimum, which is the low solar activity period with which many people are familiar (or at least have heard of). The data in figure 3 confirms that long-duration periods of low solar activity appear to occur on a somewhat regular basis.

Thus, regrettably, the data suggests we will likely have another long-duration period of low solar activity, perhaps starting with Cycle 25. What this means is you should make a maximum effort with *F2* propagation on 6 meters during Cycle 24 (hopefully, the bigger prediction will come true), as there may not be many possibilities for the next several solar cycles.

Of course, this bleak picture should be tempered with the fact that we don't fully understand the processes in the sun that generate solar cycles. For predicting sunspot cycles, we can paraphrase the caveat in stock-market investing: Historical data does not guarantee future performance. ■

In Search of the Legendary Fred Fish

For more years than we can remember, Fred Fish, W5FF, was a sometimes eccentric legend in New Mexico. Among his many accomplishments was working 488 grid squares in the contiguous U.S. Recently, the ARRL created the Fred Fish Memorial Award for anyone else who might accomplish this feat. Here W5WVO discusses a survey that revealed the grid squares most needed in order to earn this new award.

By Bill Van Alstyne,* W5WVO

I had been on a lengthy hiatus from amateur radio, but when I relocated to New Mexico in 2002 I decided it was time for me to get back in the game. As soon as I was issued my new 5-land call and returned to the air—and on a new band for me, 6 meters—I started hearing about Fred Fish, W5FF, and his wife Lee, K5FF. Although apparently no longer active on the air, their many VHF firsts were still being talked about on the Magic Band. During that first summer, I scarcely completed an *E*-skip QSO in which I wasn't asked if I knew Fred, or if I knew why he was no longer on the air. At the time, alas, I didn't know the answer to either question, but it seemed that Fred had literally put New Mexico on the VHF map for many years—not to mention a lot of other places around the U.S.!

Beyond that, though, it quickly became clear to me that Fred was very much loved in the VHF amateur community, not just as a talented and capable amateur, but as one of those rare human beings who is always ready to go above and beyond to help somebody else. It was that sense of the man that continued to grow in me over the next few years. While Fred left many VHF operating firsts behind him when he passed away in 2005, the most fondly recounted tales I heard on the air were about Fred's kindness, generosity, and enthusiasm for amateur radio.

Usually, when a person does something remarkable for the first time, many others immediately get on the trail blazed by the pioneer and follow in his or her footsteps. While this was the case for many of Fred's operating accomplishments, Fred remains the only amateur to work and confirm all 488 grid squares in the contiguous 48 United States on 6 meters.

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Photo A. Fred Fish, W5FF, remains the only amateur to work and confirm all 488 grid squares in the contiguous 48 United States on 6 meters.

Working Them All: The Fred Fish Memorial Award

Why has no one yet repeated this feat? One obvious explanation is that it is very, very hard! But beyond that, I realized, a clearly defined 6-meter operating target was needed, something really challenging toward which amateurs could work well beyond 6-meter VUCC. I felt that a good way to get this started might be to foster a prestigious operating award for duplicating Fred's singular accomplishment, and to get it sponsored in high-profile fashion.

I posted the idea on the VHF e-mail reflector in August of last year, and almost overnight I had a nucleus of three other enthusiastic amateurs—Sean Kutzko, KX9X; Kevin Kaufhold, W9GKA; and Paul Kiesel, K7CW—whose talents would synergistically mesh to make this happen. Others contributed as well, but the four of us formed the core that eventually brought the Fred Fish Memorial

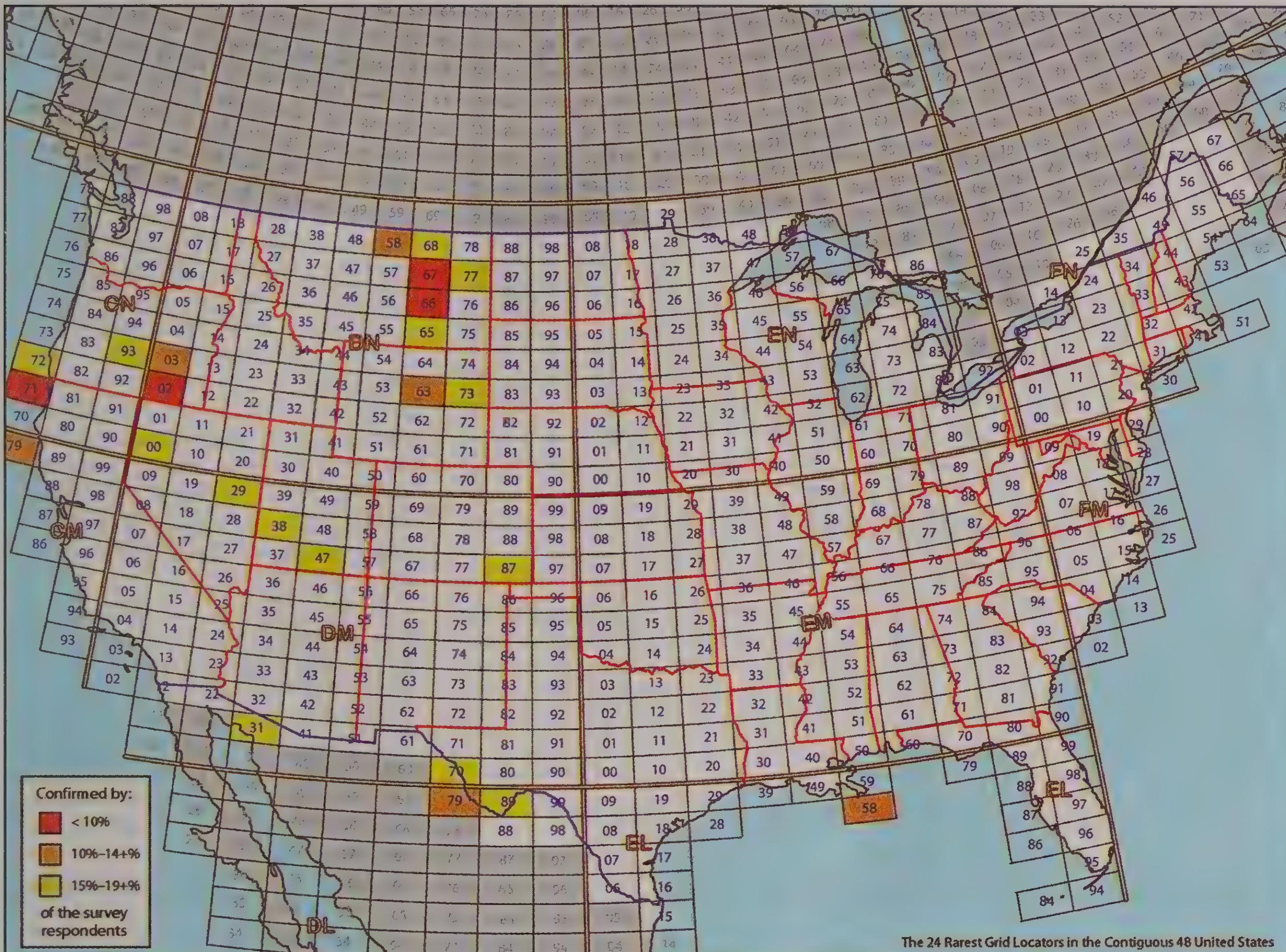


Figure 1. A map showing the 24 most-needed grid squares.

Award (FFMA) into being as a fully sponsored ARRL operating achievement award that would be the logical capstone of the VUCC program on 6 meters.

The FFMA Rare Grid Square Survey

Long before getting the FFMA approved, we began thinking about what it would take to accomplish what Fred did. First and foremost, we realized, it would take a lot of help! Many grid squares have no resident amateurs active on 6 meters, while a number of others have no resident amateurs at all. (Indeed, in a rare few, there are no resident *humans*!) Working all 488 grid squares would obviously have to be a cooperative effort involving the activation of many rare grid squares, not just for a weekend contest, but for significantly longer periods of time, like an HF DXpedition to a rare DXCC entity. A good start toward actualizing this ideal scenario, we felt, would be a credible survey of the top 6-meter amateurs in the country to find out what grids they still needed.

We wanted the results of this survey to be meaningful and statistically significant, not haphazard and anecdotal. Luckily, one of us (Kevin, W9GKA) is a statistical analysis expert, and his hard work on our survey ensured that the results possess some validity in the real world.

As in any statistical project, however, our methods and design choices are open to second-guessing. For example, we chose to heavily weight our survey towards amateurs who were already in the top tier of the 6-meter VUCC standings—and in doing so, we probably made a number of rare, inactive grid squares seem *less needed than they actually are*. Many of these rare grid squares have been activated by grid DXpeditions or contest rovers in the past, but in many cases, *way* in the past. Therefore, a few long-standing 6-meter "big guns" have had these rare grids in their logs for a long time, but no one has had a chance to work them in years, sometimes decades.

A good argument could be made for doing another survey, this time weighted towards *all* 6-meter operators who are interested in working towards grid-square awards. However, we will leave that to the future. We have a good start, and it's time to get busy activating some of these rare grid squares!

Table 1 shows the 24 most-needed grid squares from our survey, each accompanied by the state the square is in and the percent of our survey respondents who still need it.

Discussing all 24 rare grids in detail is beyond the scope of this article, but a lot of good information about them is available in the full FFMA survey report. The full report also shows the rareness ranking of all 488 grid squares, the callsigns of the amateurs who participated in the

Grid	State	% Needing	Grid	State	% Needing
DN67	MT	94.3	DM47	UT	84.1
CN71	CA	93.2	DN65	MT	84.1
DN02	OR	93.2	DN68	MT	84.1
DN66	MT	92.0	DM29	NV	83.0
DL79	TX	88.6	DM31	AZ	81.8
DN63	WY	88.6	DM70	TX	81.8
CM79	CA	87.5	DN00	NV	81.8
DN03	OR	87.5	DN77	MT	81.8
EL58	LA	87.5	CN93	OR	80.7
DN58	MT	85.2	DL89	TX	80.7
CN72	OR	84.1	DM87	CO	80.7
DM38	UT	84.1	DN73	WY	80.7

Table 1. The 24 most-needed grid squares according to the survey, including the state the square is in and the percent of the survey respondents who still need it.

survey, an in-depth discussion of the statistical analysis done on the data, and much more.[1]

Figure 1 is a map showing the locations of these rare grid squares. Consult the map key in the lower-left corner to interpret the colors. What can we observe about the survey results from looking at the map? First, all 24 rare grid squares are well to the west of the Mississippi River (except EL58, which is *on* the Mississippi). With few exceptions, the wide-open spaces of the American West predominate. Second, again with few exceptions, the grid squares tend to be clustered together in geographically homogeneous areas, often with common boundaries and/or corners.

DXpeditions to Grid Square Boundaries and Corners

This latter fact is important. In both the *CQ* and ARRL VHF contests, by rule, no station may claim to operate from more than one grid square at the same time. For the VUCC and FFMA awards, however, this rule is not in force. If a station can provide proof of being located precisely on the boundary of two grid squares or on the corner intersection of four grid squares, all of them count for credit with a single QSO! (See the FFMA rules at <http://www.arrl.org> for details on the kind of location-proof required.)

This means that grid DXpeditions to boundary or corner locations covering multiple rare grid squares are fully supported. The rare grid squares that potentially can be activated this way are clearly seen with a quick inspection of the map. Further information on the terrain and accessibility of grid square corners can be found at the website of the Degree Confluence Project at <http://www.confluence.org>.

Most grid corners and boundaries fall on private property, so mounting such an expedition requires, above all else, the explicit advance written permission of the property owner. Operating from public lands such as a national or state park, a national forest location, or from any other government-owned land requires advance permission from the appropriate government land authority.

It may be tempting to skip this step, especially if the selected location is very remote, but it's better to play it safe rather than end up getting sued or creating bad public relations for amateur radio. Always get permission *in writing* well in advance of the expedition, and make certain the request for permission is explicit about what you are going to be doing there: operating an FCC-licensed amateur radio station from (date/time) to (date/time) for the sole purpose of engaging in competitive radio sport and emergency operation preparedness exercises. Make sure any publicity that results from your operation is the positive kind!

Grid DXpeditions vs. Contest Rovers

A true grid DXpedition differs from contest roving in that it is typically fixed-portable rather than mobile-based operating, implying commensurately larger antennas and perhaps higher power. It is also expected that the grid DXpedition will stay at the operating site for more than a 24- to 36-hour contest period. This is especially important for 6-meter operation. The primary long-distance propagation mode on 6 meters is sporadic-*E*, which, as the term suggests, is unpredictable. Openings do occur regularly during the late spring and early summer months, but a day or two or three can easily pass with no openings to anywhere. If you have no sporadic-*E* propagation on the day or weekend you've allocated for the expedition, you (not to mention the potentially hundreds or thousands of hams who would like to work you in that rare grid) will probably feel that too little was accomplished for all the effort spent.

Obviously, a contest expedition to a rare grid square is better than no expedition at all, but strive to plan far enough ahead and secure the resources and commitments necessary for a more substantial operation, especially if you are going to be activating multiple rare grid squares at once. This is how the most people will make the most progress towards achieving the FFMA.

Rare Grids that Didn't Make the Top 24

Here are a few grid squares that didn't make the top 24 for various reasons but that are legitimately rare over at least the past five years or so. This is just a sampling; there are certainly more that could fall into this category.

DL88: At the extreme southernmost tip of the Rio Grande's "Big Bend," over 99% of this grid square is in Mexico. The part of it that is in Texas is a desolate, sweltering, spectacularly primitive strip of land along the north shore of the Rio Grande in Big Bend National Park. Drugs and illegal immigrants are routinely smuggled through the park, according to the National Park Service, so operating from here would require safety-related advice from both the NPS and the Border Patrol. Beyond this, an expedition must be prepared for a difficult and challenging physical environment and climate, especially during the summer months when 6-meter operating conditions are at their peak. This one has been activated in the past, and a fair number of big guns have apparently worked it, but it hasn't been activated in years. It's one of the really tough ones.

CM93, DM02, EL84: What do these three grid squares have in common? They all cover off-shore islands that are owned by the U.S. Government; none has any land area on the mainland, and none has any permanent, private, civilian resident population. CM93 covers most of Santa Rosa Island in Channel Islands National Park. DM02 covers San Clemente Island.

Owned and operated by the U.S. Navy, it has a rotating military population, as well as a varying population of temporary civilian contractors. EL84 covers Dry Tortugas National Park and the Marquesas Keys. In all cases, permission to operate must be obtained from the appropriate government agency.

FM13: Almost entirely in the Atlantic Ocean, this grid square at the mouth of the Cape Fear River covers a small portion of the village of Kure Beach, North Carolina, and some adjacent areas. There currently are no 6-meter-active amateurs living in it. While it is sometimes put on the air for a weekend during one of the summer contests, it is still a very rare grid square in need of more frequent, possibly permanent, activation.

EN67: Covering only the tiny town of Copper Harbor, Michigan, at the end of the Keweenaw Peninsula, this grid square lies almost entirely in Lake Superior. Copper Harbor's two active resident amateurs are not believed to be active on 6 meters. This grid square is sometimes activated during the June ARRL VHF QSO Party weekend, but it remains an unworked grid square for most 6-meter amateurs. This one is a prime target for permanent activation.

Permanent Grid Square Activation

While there are a few rare grid squares with no amateur population, nearly all have at least a few resident licensees, whether currently active in the hobby or not. The ideal grid DXpedition involves coordinating operations with one or more of these resident hams who is willing to be shown what fun 6-meter operation can be! The expedition station can be set up in the ham's own shack or near the ham's QTH. Help with getting permanently donated equipment and antennas set up for the resident ham could be provided. For many amateurs, once they experience running a pile-up of crazed 6-meter grid square chasers, they're hooked. This kind of operation might aptly be called "Power Elmering"!

Conclusion

Six meters is called the Magic Band because its behavior is complex and unpredictable. It can surprise you at any time with unanticipated and oftentimes seemingly unexplainable signal propagation. At one time or another, the band supports virtually all propagation modalities currently understood to exist, including *F2* (around solar cycle peaks), sporadic-E, troposcatter, meteor scatter, ionoscatter, aurora and auroral-*E*, and EME. A lot of hams, once exposed to 6 meters, immediately get hooked on it. It's a big band, and the more the merrier! The FFMA is designed to be a launching pad for ideas, operations, and enterprises that will give 6-meter activity a big bump. ■

Note

1. The full survey report is available via e-mail from the author or W9GKA. For more information on rare grid squares and to discuss rare grids and grid DXpedition ideas with other hams, consider joining the FFMA Yahoo! Group: <http://groups.yahoo.com/group/FFMA>.

The Lost Letters of KH6UK
Part 4: Project Moonbounce (1962–1964)

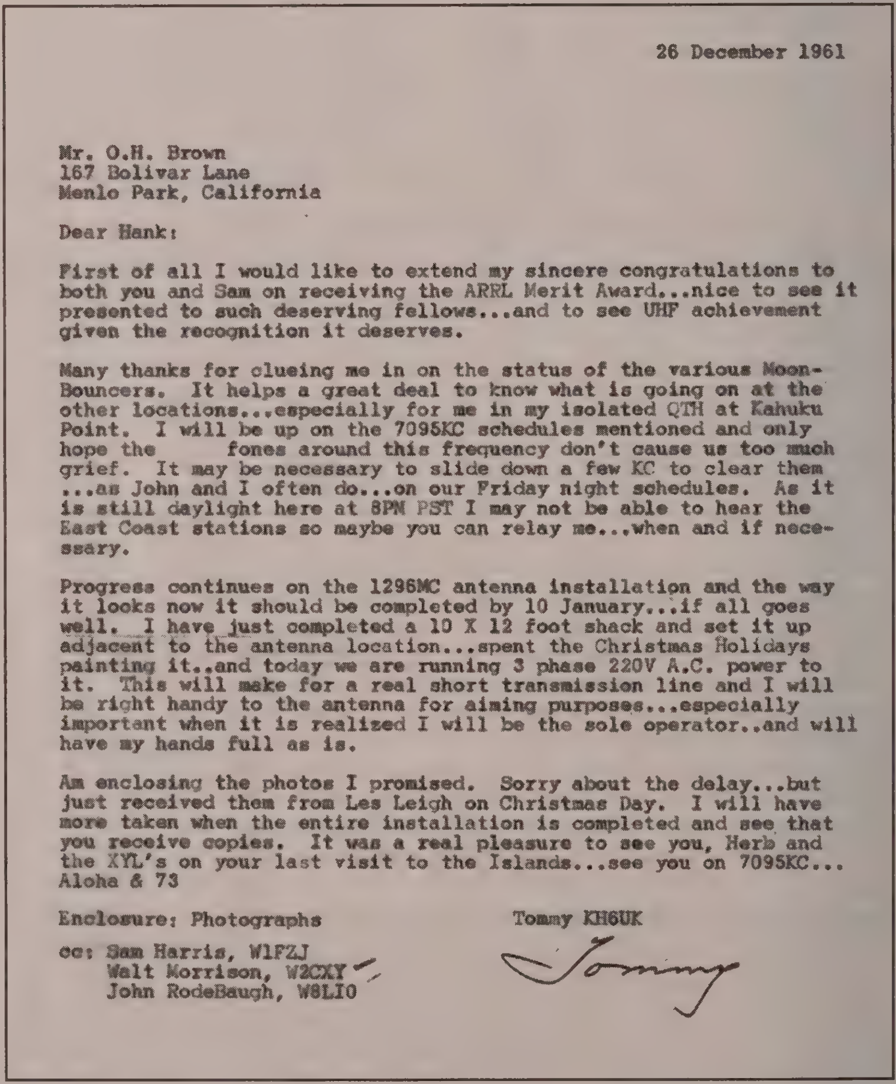
The previous three parts of this article covered Tommy Thomas, KH6UK's tropo QSO with W6NLZ, his pioneering VHF EME activities, and the effect the Klystron had on his EME work, respectively. In this concluding segment, WA2VVA discusses Tommy's involvement in moonbounce.

By Mark Morrison,* WA2VVA

By December 1961, a small group of Klystron pioneers had been formed with Hank Brown, W6HB, as its leader. Included were Sam Harris, W1FZJ, Ralph Thomas, KH6UK, John Chambers, W6NLZ, and Walt Morrison, W2CXY. Hank, who was on the West Coast end of the first moonbounce QSO in 1960, decided it was time to dust off the Klystron and give others a chance. Sam, who was on the East Coast end of that same QSO, had maintained a presence on 1296, but without any other stations to work he had not heard anything from the moon since 1960.

During this time, Sam had taken over as editor of "The World Above 50 Mc" column in *QST* magazine, replacing Ed Tilton, W1HDQ, who held the reins for over 20 years. This put Sam in a unique position to not just talk about moonbounce, but to challenge others to join in. At least two other hams who didn't seem to have Klystrons took up that challenge. These were John Rodebaugh, W8LIO, of Dorsett, Ohio and Dr. Karl Lickfield, DL3FM, of Germany.

Although Sam could reach out to a wider potential audience through *QST*, publishing deadlines meant information was often dated, sometimes by a month or more. Hank picked up where Walt and Tommy had left off, writing letters to all interested parties and sharing up-to-date information with each. Many times he'd



26 December 1961

Mr. O.H. Brown
167 Bolivar Lane
Menlo Park, California

Dear Hank:

First of all I would like to extend my sincere congratulations to both you and Sam on receiving the ARRL Merit Award...nice to see it presented to such deserving fellows...and to see UHF achievement given the recognition it deserves.

Many thanks for clueing me in on the status of the various Moon-Bouncers. It helps a great deal to know what is going on at the other locations...especially for me in my isolated QTH at Kahuku Point. I will be up on the 7095KC schedules mentioned and only hope the fones around this frequency don't cause us too much grief. It may be necessary to slide down a few KC to clear them ...as John and I often do...on our Friday night schedules. As it is still daylight here at 8PM PST I may not be able to hear the East Coast stations so maybe you can relay me...when and if necessary.

Progress continues on the 1296MC antenna installation and the way it looks now it should be completed by 10 January...if all goes well. I have just completed a 10 X 12 foot shack and set it up adjacent to the antenna location...spent the Christmas Holidays painting it..and today we are running 3 phase 220V A.C. power to it. This will make for a real short transmission line and I will be right handy to the antenna for aiming purposes...especially important when it is realized I will be the sole operator..and will have my hands full as is.

Am enclosing the photos I promised. Sorry about the delay...but just received them from Les Leigh on Christmas Day. I will have more taken when the entire installation is completed and see that you receive copies. It was a real pleasure to see you, Herb and the XYL's on your last visit to the Islands...see you on 7095KC... Aloha & 73

Enclosure: Photographs

Tommy KH6UK

Tommy

cc: Sam Harris, W1FZJ
Walt Morrison, W2CXY
John RodeBaugh, W8LIO

Figure 1. The December 1961 letter from Tommy to Hank, W6HB, the last of Tommy's written letters in the W2CXY collection.

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e-mail: <mark1home@aol.com>

Figure 2 and Photos A, B, and C courtesy of QST *and the ARRL.*

copy the letters received from others and distribute those as well. In a letter dated December 19, 1961, Hank had this to say:

While on vacation, two weeks ago I visited Ralph Thomas, KH6UK. Here is a real doer. Tommy's transmitter is all rack and cabinet mounted, power supply complete, exciter operating. His receiver is essentially ready to go. And the biggest news of all to me was that his 28-foot dish would be in the air on an ex-radar pedestal by the end of this month!

Even the really big problem of a decent antenna switch has been solved by Tommy—and beautifully.

All Tommy needs to do is get all the stuff in the operating position and KH6UK will be in business on 1296 mc. Tommy, at last, has a capable helper or two and things are really moving.

Also attached are letters from Walt Morrison, W2CXY, and John Chambers, W6NLZ. Each of these two is really getting there, and will be pushing sizeable signals moonward quite soon.

At about this same time, both Hank and Sam received the ARRL Merit Award for their successful first amateur moonbounce QSO. In December of 1961 Tommy wrote Hank a letter (figure 1), which is the last of Tommy's written letters in the W2CXY collection. As Tommy mentioned in his letter, the gang was using a liaison frequency of 7095 kc. Hank had proposed that everyone meet on this frequency on Wednesday and Friday evenings "for information exchange only so we can keep abreast of activities."

In addition to the letters that Hank distributed to others, he also issued minutes of the various meetings held by the West Coast gang working on the project. To read these minutes, portions of which are shown below, is to appreciate the scope and teamwork that is involved in a successful moonbounce operation. Here's what Hank reported in one such letter:

Transmitter:

The stable crystal oscillator and multiplier, built by Dave Meacham, and its power supply, built by Bernie Coler, have been finished and all is working well. The stability is excellent. It has been used to drive Willie Sayers' 1296 exciter and performs nicely. The Klystron tuning boxes have been built and are in San Bruno with the rest of the transmitting equipment which is waiting to be assembled. It will be put together and run into a dummy load before it is brought down to the transmitter shack in San Carlos.

Antenna:

The antenna dipole radiator has been built by Al Clark [W6MUC] and Dick Kramer. All that remains is to fit the antenna assembly to the coaxial transmission line, about a two or three hour job.

Receiver:

Hugh Macdonald [W6CDT] and I moved the receiving equipment out to the shack. The coax change-over switch has been mounted on the wall. An interlock switch has to be mounted on the change-over switch to protect it from an accidental turn on of the transmitter; that is probably about a two hour job.

In January 1962, Sam Harris made it official by publishing the news that the West Coast 1296-MHz operation was being reactivated. In that month's *QST* magazine he announced that Ray Renaudo would be the chief engineer. Sam also mentioned that Bill Ashby, K2TKN, was writing an article on the UPX-4 modification, which would bring 1296-MHz capability to those without a Klystron.

While Tommy and the West Coast stations enjoyed relatively good weather during the winter of 1961–1962, the East Coast stations were getting pummeled with heavy snow and damaging coastal storms. Sam reported in *QST* that "cooperation from the east coast end has been rather poor due to the extreme winter conditions involved. W8LIO had his dish buried in snow for the past two months and only last week was able to get in to his operating position without the use of dog sleds."

The spring of 1962 wasn't much better, with a major coastal storm wreaking havoc on New Jersey and the operations at W2CXY. As bad as the weather was, however, preparations continued for the upcoming moonbounce season. By March 1962, both Walt and Tommy were ready to give moonbounce a try with Sam and possibly one another. On the evening of March 15, 1962, Walt's team—which included Ed O'Connor, W2TTM, Carl Scheideler, W2AZL, Bill Ashby, K2TKN, and a few others—gathered at Walt's QTH in Chatham, New Jersey to fire up the Klystron and "shoot for the moon." That evening W2CXY succeeded in bouncing his 1296-MHz signal off the moon and into the dish of W1BU in Medfield, Massachusetts. Sam had this to say in the May 1962 issue of *QST* (p. 150):

W2CXY and his group of basement engineers, which includes such notables as W2AZL, K2TKN, K2GQI, W2HAC, and others too numerous to mention, are also on the air both transmitting and receiving. As a matter of interest I did receive a short transmission from them by way of the moon on the night of March 15—the first moonbounce signal we have heard at W1BU since August of 1960.

RECORDS

Two-Way Work

50 Mc.: LU3EX — JA6FR
12,000 Miles — March 24, 1956
144 Mc.: W6NLZ — KH6UK
2540 Miles — July 8, 1957
220 Mc.: W6NLZ — KH6UK
2540 Miles — June 22, 1959
420 Mc.: SM6ANR — G3JHM
686 Miles — August 31, 1961
1215 Mc.: W1BU — KH6UK
5092 miles, — August 9, 1962
2300 Mc.: W6IFE/6 — W6ET/6
150 Miles — October 5, 1947
3300 Mc.: W6IFE/6 — W6VIX/6
190 Miles — June 9, 1956
5650 Mc.: W6VIX/6 — K6MBL
34 Miles — October 12, 1957
10,000 Mc.: W7JIP/7 — W7LHL/7
265 Miles — July 31, 1960
21,000 Mc.: W2UKL/2 — W2RDL/2
14 Miles — Oct. 18, 1959
Above 30,000 Mc.: W6NSV/6 — K6YYF/6
500 Feet — July 17, 1957

Figure 2. Tommy's VHF accomplishments as reported in the May 1963 issue of QST.

Considering that Walt's signal was the first to be heard by Sam since 1960, W2CXY appears to be the third amateur station to ever reflect a 1296-MHz signal off the moon to be heard by another station. Others were soon to follow, but for Walt a dream had already come true.

It was about this time that things were really heating up. Sam reported in May 1962 *QST* the considerable progress of the many other stations as follows:

As a culmination of the long winter nights' activities, we have received a sudden increase in enthusiasm on 1296 moonbounce. W6AY, headed by Hank Brown, and the rest of the Eimac Radio Club have their new eighteen-foot dish installed and ready to operate; more contacts with this group are quite likely to occur within the next month…

K9KEH and company, consisting of W9ZOG, K9CNN and W9SQR, are on the air operating from Doc's QTH in Chicago, Illinois. K9KEH will be running the ubiquitous Eimac 3K2500LX [Klystron] in the transmitter and is using a polar mounted dish complete with parametric amplifier in the receiving department. This installation should operational by the first of April…

W8LIO, who now has his 24-foot polar-mounted dish on automatic track and has been hearing the moonbounce signals from W1BU for the past two years, will be operational on transmit by the end of April. Jack, to date, is the king of the do-it-yourselfers with everything homemade including the dish…

W6NLZ indicates that he will be operational moonbounce before the 1st of April. He has been on the air with a fixed dish for the past year…

We understand that Tommy, KH6UK, is also operational on 1296 with a 28-foot dish capable of being aimed at the moon. This would be the farthest DX presently set up to operate and naturally everyone is holding his breath waiting to hear this signal…

W1BU is operational using our old equipment into the 19-foot polar mounted dish and at this writing is the only station capable of receiving its own echoes from the moon…

DL3FM has his transmitter and receiving system completed, his polar mount and tracking system is built, and as of the last letter he is only awaiting the spring thaw to mount the dish on the polar mount, at which time he will be in operation…

HB9RG has his transmitter and receiver in operation and is presently using an 8-foot parabolic dish on a non-tracking mount…

WA6JZN and his crew in the northern California area have been more or less operational for the past six months.

K6MIO from Fresno, California, is making completions on his 1296 receiving setup and expects to be operational, receive only, by the middle of April.

Sam reported in the June and July issues of *QST* that KH6UK also succeeded in getting his signal into W1BU about two weeks after Walt, on April 30th and then again on May 1st of 1962. In the months that followed, Sam would report numerous times that he could hear KH6UK via the moon, but it wouldn't be until July of 1962 that Tommy would hear W1BU coming into Kahuku. Finally, on August 9, 1962 they made it a two-way, adding one more record to Tommy's impressive string of VHF accomplishments as shown in figure 2 from *QST*.

Tommy's 1296 station was located in a small building not far from his house and situated within visual range of the RCAC towers (photo A). Reminiscent of a radio shack from the 1920s, save the dish mounted on top and the heavy three-phase power line used to power it, Tommy must have felt right at home there. Printed signs on the outside as well as inside the shack read "AB6UK."

The inside of Tommy's shack was full of equipment (photos B and C). Much of his regular station was relocated from the house to the shack, including his trusty Hallicrafters receiver and his new Racal. His Klystron and supporting equipment were also close at hand, making it handy for a one-man operation.

In the years that followed, Tommy would set his sights on 432 MHz. He once commented to Walt Morrison that if the FCC ever lifted the power restriction on that band he would like to use it for moonbounce. In 1964 the FCC did just that, and on July 31, 1964 Tommy worked W1BU, setting another world DX record, this time for 432 MHz. By this time Tommy's record 2-meter contact with W6NLZ had been replaced by another moonbounce contact, that of W6DNG and OH1NL (144 MHz, 5,250 miles, on April 11, 1964).

Photo A. Tommy's 1296 station was located in a small building not far from his house and situated within visual range of the RCAC towers. (Photo from the September 1962 issue of QST*)*

Photo B. The inside of Tommy's shack. was full of equipment, including his trusty Hallicrafters receiver and his new Racal. (Photo from September 1962 QST*)*

Photo C. Tommy's Klystron and supporting equipment were also close at hand. (Photo from September 1962 QST*)*

Tommy would have been particularly interested in this contact. When he first arrived on the island it was every VHF man's dream to do moonbounce on 144 MHz. Tommy had spent many years working on this project with W2CXY and others. Following the successful tropo season of 1957, W6DNG was one of the hams who contacted Tommy about possible 2-meter schedules. A picture of the 2-meter antenna used by W6DNG for this first moonbounce contact bears a striking resemblance to one of Tommy's designs, suggesting perhaps they, too, had corresponded on the subject. Perhaps what is most significant about the W6DNG/OH1LN QSO is that it represented the first transatlantic contact above 50 MHz.

By November 1964 Tommy's three-year hitch was up, and he returned to the mainland and his old call, W2UK. Settling in Colt's Neck, New Jersey, Tommy was close to where Carl Scheideler, W2AZL, lived, and it appears that Tommy joined Carl and another ham, WA2WOM, for one more shot at 2-meter moonbounce. That they succeeded is evident by an excerpt from the popular series of moonbounce notes published by Eimac in the 1970s (figure 3). This time an array of four 14-foot log-periodic antennas was used, quite modest compared to some of the designs Tommy employed years earlier.

In the years that followed, Tommy and his friends would slowly disappear from the scene until finally there was little mention of them in the press. Even now, their calls may be recognized, but their achievements are often misunderstood. Tommy's last known address was Farmingdale, New Jersey, where he became a Silent Key on May 8, 1996.

Tommy was always interested in the accomplishments of others and quick to give them praise. In written and taped letters to W2CXY, Tommy expressed his appreciation for the way that Walt and others, including W8KAY, maintained a steady flow of information to other interested parties. This was no easy task, but

Call	Antenna
WA2BIT	80 el. (going to 160 el. collinear)
WA2WOM	4-12 el. SWAN-LPY
W2AZL	4-14 el. SWAN-LPY
W2UK	4-14 el. SWAN-LPY
K4GL	80 el. collinear
K4IXC	8-7 el. Yagi
WA5UNL	16-5 el. Yagi
K6MYC	192 el. collinear (now down)
WA6LET	150' dish
WA7KYZ	16-5 el. Yagi (going to 8-14 el. LPY)
K8III	80 el. collinear (going to 320 el.)
W8KPY	4-15 el. Yagi, 4-16 el. KLM, 8-16 el. KLM (down)
K9HMB	160 el. collinear
KØMQS	8-15 el. Yagi
KØWLU	8-11 el. Yagi
WAØCHK	4-15 el. Yagi
KH6NS	64-3 el. Yagi (now down)
DK1KO	4-11 el. Yagi
SM7BAE	16-10 el. Yagi
VE2DFO	160 el. collinear
VE7BQH	160 el. collinear
VK3ATN	Rhombic (now down)
VK5MC	Rhombic
SMØAPR	40 el. collinear
K3PGP	96 el. slot

Figure 3. Stations worked on 144 MHz EME by W6PO as of August 1974. (Published by Eimac in the 1970s)

it served to encourage others who might otherwise have lost interest or suffered discouragement for one reason or another. In those days, the US Mail service provided an important link between distant VHF stations.

Although Tommy would often joke with W2CXY that "they might beat us to the punch" when talking about 2-meter moonbounce operations, he was not discouraged that someone else might be first. One possible reason is that no matter who broke the ice first, Tommy's location in the middle of the Pacific would almost guarantee him a place in the record books if he could just work an East Coast station via moonbounce.

Although he did just that, Tommy's interest was about more than setting records. He had a concern that amateurs, especially in the VHF/UHF spectrum, were not using their privileges and getting the recognition that they deserved. His pioneering efforts were to be examples for others to follow. Indeed, Sam Harris credited Tommy and John's spectacular tropospheric contacts with generating increased interest in these bands.

Today the amateur radio operator faces many more challenges from commercial interests than ever before. If Tommy were still with us, I'm sure he'd be busy pushing the envelope on the UHF bands and encouraging others to follow.

In publishing the "Lost Letters," I hope to have stirred things up a bit, in the tradition of Tommy, so that others might be inspired to face those challenges with the same confidence and determination that Tommy demonstrated over 50 years ago.

Epilogue

In 2004 the house that served as a home to your author and the QTH of W2CXY was sold. Before turning over the keys, my brother and I had one last look at the place. Although the furnishings were gone, and remainders of amateur radio had long since been removed, one vestige of the Klystron era survived.

Looking up at the floor joists in the area where the Klystron had once been located, high up where you wouldn't expect the find anything, seven nails could be seen sticking out of the wooden floor joists. Above each nail was a piece of tape with a different callsign on it. The calls listed are familiar to us now, with KH6UK, W6SC, W6AY, W6HB, and W1FZJ all represented. At first I didn't know the significance of these calls, but as a result of writing this series I now realize these were the calls of the moonbounce pioneers and the nails were used to hang the punched tapes that W2CXY would prepare for use with his Boehme high-speed keying head. The house may be gone, but what happened there so many years ago will never be forgotten.

In closing, I would like to express my sincere gratitude to Joe Lynch, N6CL, and the many people at *CQ VHF* magazine without whose support and cooperation the story of KH6UK and his friends might have been lost forever. ■

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

New Gear for 1.25-meter Foxhunting

"I found it!" Few things are more satisfying to me than the surprised exclamations of youngsters as they locate hidden radio transmitters for the first time. This "Aha!" moment is the payoff for their intense concentration and competitive spirit. It's their realization that ham radio activities can be great fun, and it's a powerful stimulus for them to learn more about radio waves and propagation.

Wouldn't it be great if more young people could experience hidden transmitter hunting on ham radio? As I try to promote this idea, one of the most common responses from hams and youth leaders is "We don't have any equipment." I reply that tape measure beams[1] and offset attenuators[2] are easy and educational for young people to build, but I realize that many groups just want an "out of the box" system. Now it is available.

Communications Specialists of Orange, California is offering miniature transmitters and matching radio-direction-finding (RDF) receiver/antenna sets for the 222–225 MHz ham band. ComSpec's owner is Spence Porter, WA6TPR. His company gained success making subaudible tone encoders and decoders back when hams were first discovering the joys of VHF-FM and repeaters. As transceiver models with built-in CTCSS came out that market diminished, and he turned his efforts to radio tracking equipment for many uses, both licensed and unlicensed.

Two years ago I wrote about ComSpec's tiny transmitters for 218–220 MHz.[3] At the time, these unlicensed emitters were being marketed to pet owners and to flyers of model airplanes and rockets in the USA and elsewhere. Now sold only to foreign customers, this tracking system has 50 channels at 25-kHz intervals from 218.025 through 219.300 MHz. The PT-1 series transmitters put out 28-millisecond pings of unmodulated RF, about 47 per minute. One CR2032 lithium battery, about the size of a quarter, provides a month of continuous operation. As its battery reaches end of life, the transmitter double-pings every 10 seconds as a warning.

For RDF, the mainstays of this ComSpec line are the PR-30 LoCATor and PR-50 R/C-ELT receivers. Both feature a beat-frequency oscillator (BFO) and CW/SSB detector that turn the dits into tone pings. A peak-reading meter makes it easy to distinguish signal-level changes of the pings while turning the supplied FA-1 two-element folded Yagi. This 8" × 20" Moxon rectangle beam is fabricated from circuit-board material and weighs only 101 grams (3.5 ounces).

FCC Giveth and Taketh Away

Unlike the "squegging" oscillators[4] in most wildlife tracking transmitters, ComSpec's little emitters use an elegant temperature-compensated crystal-oscillator (TCXO) design that provides excellent frequency stability and harmonic suppression.

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WA6TPR designed the PT-1 to meet FCC Part 15 emission limits for unlicensed operation, when used with a 2.5-inch whip antenna embedded in a pet collar or trailing behind a model plane. RF field strength had to be less than 200 microvolts/meter at 3 meters distance, in accordance with FCC 15.209. ComSpec contracted with an engineering consulting firm to make compliance measurements. Then Spence applied for and received FCC Part 15 certification in April 2004.[5]

Over two years later, the FCC requested a sample of the PT-1, tested it, and declared that it exceeded Part 15 limits. The Commission rejected the consultant's test data, saying that a peak detector should have been used instead of a standard quasi-peak detector.[6] ComSpec received a demand to cease and desist, as well as to pay a $7000 fine.

Believing that the peak-detection clause in FCC 15.35 doesn't apply to millisecond-ping transmitters, ComSpec dis-

Is it in the tree? At a Scout-O-Rama two years ago, this Cub Scout discovered that a pet-tag signal was coming from above. He was searching with a ComSpec PR-50 receiver and FA-1 Moxon beam. (All photos by Joe Moell, KØOV, unless otherwise noted)

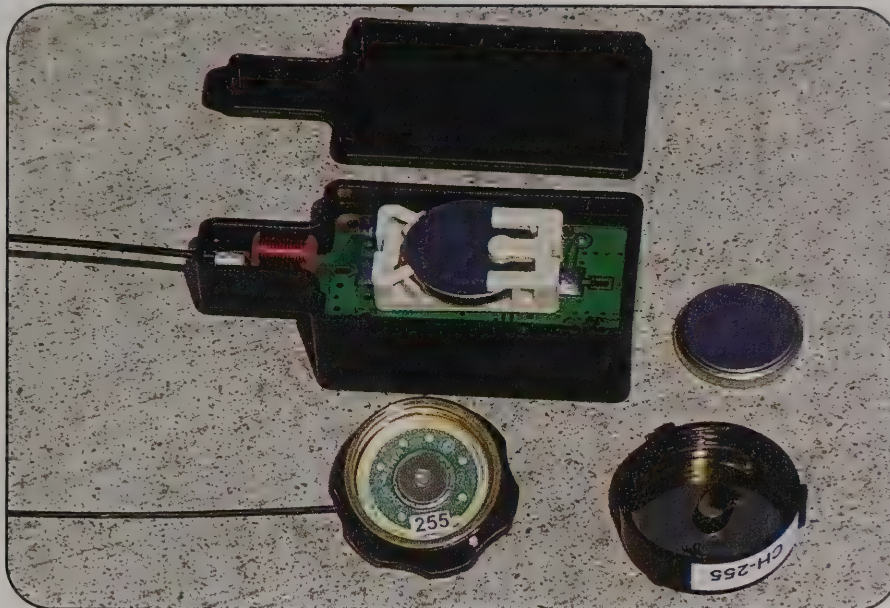
puted the FCC's finding. However, the Commission wouldn't budge. It didn't make any difference whether a mistake or rule misinterpretation was made by ComSpec, the consultant, or the government agency. It didn't matter that the FCC had previously reviewed the data and issued a certification. In the eyes of the regulators, the new decision was final and the buck stopped with the owner of ComSpec.

How many PT-1 sales would it take to pay for a Washington attorney? Far too many, Spence decided. Thus, he avoided a lengthy and expensive legal battle by entering into a consent decree,[7] paying a reduced fine, and withdrawing the PT-1 from sales to U.S. individuals.

Under the FCC's rule interpretation, WA6TPR says that there is no way the PT-1 could be revised to be Part 15 certifiable while still being effective for pet tracking. "When the FCC decided that quasi-peak didn't apply, that whacked our legal output by 15 dB," he explained. "What's galling is that we're not over the Class A limit for 'non-intentional radiators' in 15.109(b). If this were a copy machine in an office, it would be certifiable with this output because that is measured at 10 meters away. But since this is an 'intentional radiator' in a home, the FCC says that the measurement must be at 3 meters away. To meet that, the transmit antenna would have to be cut down to one-half inch long, and then the signal wouldn't get two houses away."

A last-ditch possibility was FCC 15.231(e), which allows intentional radiators with periodic transmissions at 218 MHz to put out a whopping 1500 microvolts/meter peak. Unfortunately, for that section to apply, the silent period between transmissions would have to be at least 10 seconds. Imagine trying to get a bearing on a moving cat or model plane in a signal-reflection environment with only six pings per minute. Therefore, ComSpec has been forced out of the USA's unlicensed pet and model aircraft tracking market.

Fortunately, there are other stateside customers for these 218-MHz pingers. Wildlife researchers may put them on non-domestic cats and birds under FCC 90.248. This must be done with an FCC license and it is limited to commercial and educational organizations. For tracking critters that don't fly, the rule permits 10-milliwatt transmitters. ComSpec sells the PT-2W wildlife tracking collar for this purpose.



Both the AT-2B 50-milliwatt transmitter (top) and AT-1B one-milliwatt transmitter operate from CR2032 lithium coin-cell batteries. The AT-1B can benefit from an added quarter-wavelength counterpoise (not shown), connected to the positive battery contact in the screw-on cap.

Another important market is forensic surveillance and tracking. Any law enforcement agency with suitable jurisdiction may use 218-MHz transmitters in the unlicensed Low Power Radio Service under FCC 95.1009 for homing or interrogation. Up to 100 milliwatts effective radiated power is permitted. ComSpec's PT-2A puts out 95 milliwatts for several miles of range.

Plug-and-Play Foxhunting

Will ham radio become another successful market for ComSpec RDF equipment? Coverage of 222–225 MHz was a simple matter of shuffling counters in the phase-locked loops of transmitters and receivers. WA6TPR says that licensed hams who fly model aircraft and rockets are welcoming a greater-range alternative to Part 15 devices for recovery of their expensive flight hardware. "Model planes do pretty well with one milliwatt and an extended antenna," he told me. "They don't go too far, but a rocket can get caught in the upper winds and get several miles away pretty quick."

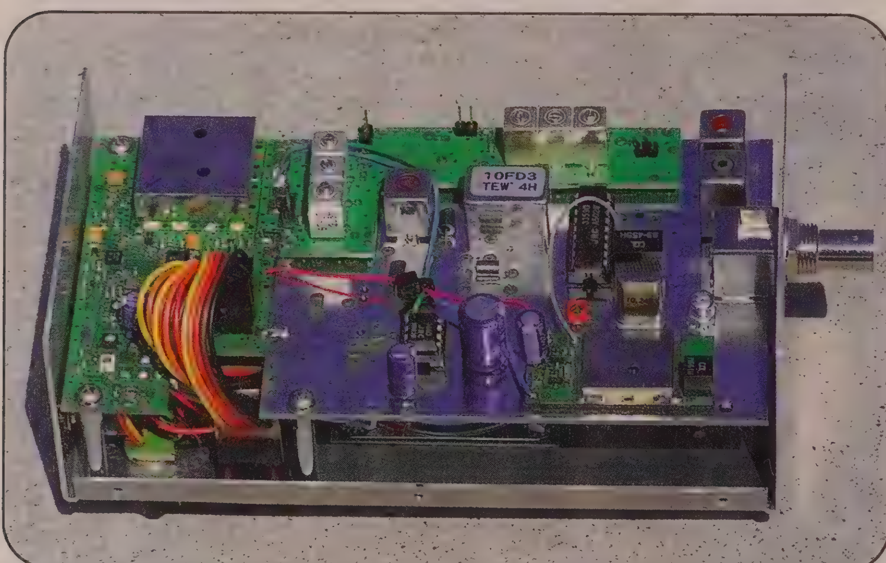
In most parts of the USA, the 1.25-meter band is very quiet, with just a few repeaters and simplex users. However, in southern California, where I live, every available repeater pair is assigned and there is plenty of other on-air activity. No open space exists for a block of channels dedicated to low-power transmitter hunting, but unmodulated dits can fit nicely between repeaters, which are 20 kHz apart. ComSpec has identified 128 RDF frequencies between the southern California 220 Spectrum Management Association's coordinated repeater/simplex channels. "The low end of my group is 222.07 MHz, avoiding QRM to weak-signal, EME, and propagation beacon operators," Spence says.

Freed from the tight constraints of Part 15, WA6TPR engineered his 1.25-meter emitters based on practical considerations, such as size, weight, and battery life. The AT-1B foxhunt transmitter is an upgrade of the PT-1, with a screw-on battery cap to make it waterproof. It is rated at one milliwatt output and can be ordered on 23 of the 128 interstitial frequencies, from 222.15 through 223.35 MHz.

This little 12-gram transmitter is very easy to camouflage for foxhunts in the park. Conceal it in an old cell-phone case or an empty soda can. With a little green or brown tape, it blends nicely in a bush. It could even be built into a twig, just like Paul Austin, N2TAJ, did with a different model of transmitter for the Xerox Amateur Radio Club's CQ World-Wide Foxhunting Weekend event in 2007.[8]

The AT-1B comes with an 8-inch flexible wire antenna, attached with a 2-mil-

ComSpec's new R-300 receiver and FA-3 Moxon antenna. The elements fold out and click into place.



Inside the R-300 receiver.

limeter eyelet. You could easily substitute another kind of radiator, but what about the return? No "shield" or "ground" connections are provided.

"Battery positive is only about 200 ohms from circuit common," Spence told me. "There are capacitors around this resistance, so it's a dead short at VHF. All you need to do is attach your counterpoise or coax shield to the battery cap where it comes into contact with the positive terminal."

For much greater range, ComSpec has adapted a little Part 95 rig that is being sold to law enforcement. At 40 milliseconds, transmissions from the AT-2B are the length of a CW dit at 30 wpm. Normal rate is 54 dits/minute. The RF section is potted in epoxy, making it moisture-resistant and crash worthy for model aircraft use. With the same type of coin-cell battery, the 28-gram AT-2B will stay on the air for about five days. All 128 RDF channels are available.

"The PT-2A law transmitter can put out 95 milliwatts," Spence explains. "However, a coin cell can't provide the peak current required for that. You only get 50 milliwatts and about a week of operating time on a CR2032. For the full 95 milliwatts and a month of continuous operation, you could modify your AT-2B for a CR123A lithium photo battery in a plastic holder."

The stock AT-2B antenna is a 10-inch spring-wire whip, base-loaded with a surface-mount inductor. According to WA6TPR, this approximates an end-fed half-wavelength radiator, so no counterpoise is needed. "We have our own little antenna range here," he says. "I can put anything on my turnstile and test it, make changes to it, and optimize it for best field strength. That's what I did with the AT-2B."

If you want to attach coax to the antenna of your choice, Spence says that the AT-2B RF block's output impedance is close to 50 ohms. You can connect to it right at the circuit board. If you do this, be sure to remove both the whip and the inductor.

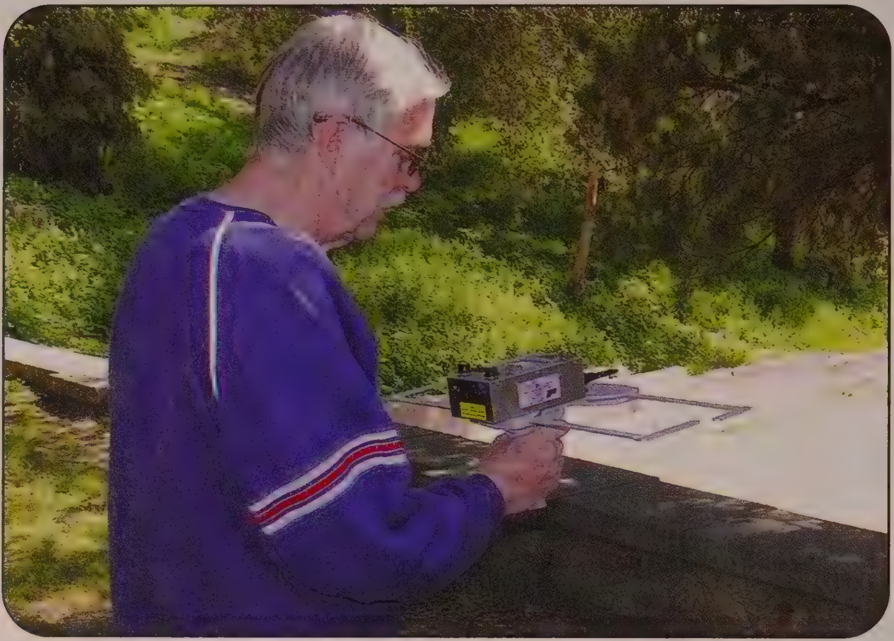
ComSpec programs your callsign into each of your AT-1B and AT-2B transmitters, to be sent in CW every 10 minutes. To make foxhunting easier for beginning Scouts, WA6TPR says he can program the cycle for longer or more frequent dits, with a corresponding reduction of battery life.

Narrower is Hotter

For tracking these little ditters, ComSpec's least expensive receiver (about $250) is the PR-100. It starts with the basic PR-50 218-MHz R/C plane locator model and adds 50 additional channels at 20-kHz intervals from 222.250 through 223.230 MHz. As I wrote last time, this is a "hot" receiver. The IF bandwidth is much narrower than the typical 12 kHz of FM receivers, giving the PR receivers better signal-to-noise ratio on dits.

On my bench, the PR-50 could detect a 25-nanovolt signal, which was a 14-dB advantage in RDF sensitivity over a typical NBFM scanner. For closing in, RF attenuation is built in, with a three-step range switch and gain control. A 1 3/4-inch speaker puts out lots of sound, so you won't have to strain your ears. A 9V battery tray allows rapid battery changes.

Although the PR-100 and FA-2 will do nicely for foxhunting at the park in cities and towns where the 1.25-meter band isn't crowded, the newest addition to the ComSpec RDF line is a big step up. The R-300 has an added 8-pole SSB-type filter at the first IF frequency. This nearly eliminates adjacent channel interference from NBFM signals. I could only hear



Tom Fiske, AA6TF, searches for a 222-MHz horizontally-polarized mini-transmitter at a foxhunt in Fullerton, California using the R-300/FA-3 combination.

Healthy Indiana Bats such as this one were fitted with radio tags in a study by the New York State Department of Environmental Conservation. (Photo by Pat Browns, WN8Z)

weak audio "scratches" from a local mountaintop repeater when I tuned 10 kHz on either side of it. The narrower bandwidth (4 kHz at –70 dB) provides further improvement over the PR-100 in signal-to-noise ratio to boost the effective RDF range.

The R-300's synthesizer is thumbwheel-tuned at 10-kHz intervals over the entire band, from 222.00 through 224.99 MHz. A fine-tuning knob smoothly adjusts the ping tone from about 500 to 1500 Hz. The RF front end has MOSFET preamplification and six helical-resonator bandpass filters. Most foxhunters prefer to wear headphones, so an audio output jack has been added.

There is a third receiver option for those who already own a ComSpec LoCATor or R/C-ELT set. Some models can be factory-modified to add 1.25-meter coverage, for a total of up to 400 channels.

Ergonomic Redesign

Two years ago, Spence and I discussed a version of his tracking system for the amateur 1.25-meter band and the potential for hams to use it with youth and Scouts. My opinion was that young kids needed a better way to hold the aluminum-cased receiver and antenna while foxhunting. Spence took my suggestion of adding a hand grip to the bottom of the R-300 receiver, near the balance point. Then he went further by designing a new version of the Moxon antenna with fold-out elements that click into place on a rugged plastic body.

Width and thickness of the aluminum elements on the new FA-3 antenna widen its frequency range. I measured 1.6:1 SWR over the full 1.25-meter band. Of course, directivity is much more important than SWR for a receive-only RDF beam. The Moxon's directional pattern is excellent. A quick check with a calibrated attenuator in series with the feed point confirmed that the rear-pattern null is about 20 dB deep. With the metering of the R-300, that is the difference between near zero and full-scale reading at some signal-strength levels.

Instead of attempting to measure the Moxon's forward gain, I decided that it would be more worthwhile to check the range of the complete ComSpec RDF system. I mounted two AT-1B and two AT-2B transmitters at equal heights on a non-metallic support about three feet above my single-story rooftop. All were on different channels and had fresh CR2032 batteries. They were oriented for vertical polarization to give an omnidirectional pattern in azimuth. To one of each model I added a quarter-wavelength (6.5-inch) vertical counterpoise hanging down, connected to battery positive. Then I headed out with the R-300 and FA-3.

The one-milliwatt unit got a definite range boost from the added "tiger tail."[9] I couldn't hear the stock AT-1B at 0.8 miles, but the one with the counterpoise was still strong enough to get a good bearing there. Maximum range was about a half mile for the stock unit and 1.2 miles for the modified one.

The two 50-milliwatt AT-2 ditters got out much farther, of course, but the added counterpoise made range worse instead of better. The stock AT-2B was weak but good enough to get bearings at 4.5 miles, whereas the modified unit couldn't be heard beyond about 3.5 miles. I haven't tried a CR123A battery to get 95 mw yet, but that should increase range by 38 percent, all other factors being equal.

My tests were in metropolitan Orange County, California. Even though 1.25 meters has less ambient noise than 2 meters in urban areas, I still found plenty of QRN to contend with. Hams using this system for tracking model aircraft in the electrically quiet desert should get noticeably greater effective range.

The biggest downside of the ComSpec receiver is still the weight. At almost two pounds for the R-300/FA-3 assembly, it's no problem for a teenager, but it's a lot for a third-grader to hold up and wave around for the duration of a foxhunt. If range isn't an issue, a tape-measure beam and small scanner such as the ICOM IC-R10 might be easier for young Scouts, for example, to manage.

Another solution for the young ones would be to separate the R-300 and FA-3. Hang the receiver on a harness around the neck, with the meter facing up so the child can see it. Then he or she would only have to hold up the antenna.

Our annual Scout-O-Rama in a big park will take place in just a few weeks as I write this. I am looking forward to setting out these 1.25-meter ditters among the many hidden transmitters that the Scouts will find.

White Nose Syndrome Threatens Bats

Tiny pinger transmitters are still an important tool for studying wildlife behavior. In "Homing In" for Summer 2005 *CQ VHF*, I told the story of some RDF-savvy hams who helped researchers during a radio-tag study of endangered Indiana Bats leaving their winter cave hibernation in New York State. At that time, the population of the species had been dropping steadily and there was concern about human encroachment on their habitat and food sources.

Now these bats are facing an even more serious threat to their survival from a mysterious condition that is causing them to wake up from hibernation early, burning their winter fat too soon. According to an Associated Press report, thousands of Indiana Bats have been found dead with a white ring of fungus around their noses. Biologists want to know if the fungus is the cause of death or just an indication that the bats had gotten too sick to perform self-grooming.

Up to 90 percent of the bats in some caves have perished. Loss of this population could have serious consequences, because they feed on insects that are damaging to crops. Researchers have been carefully trekking the caves in search of clues, wearing HazMat suits to prevent further danger to the remaining bats. The results of their efforts will determine whether radio-tag studies will take place in future years.

Your RDF-related news is always welcome. Please send electronic or postal mail to my addresses at the beginning of this column.

73, Joe, KØOV

Notes

1. <http://www.homingin.com/equipment.html>
2. <http://www.homingin.com/joek0ov/offatten.html>
3. "Homing In: RDF for the Masses," *CQ VHF*, Spring 2006 issue, has details of the ComSpec Part 15 tracking system and Moxon beam antennas.
4. <http://www.homingin.com/joemoell/squegg.html>
5. FCC ID CFXPT-1
6. <http://www.ieee.org/organizations/pubs/newsletters/emcs/summer01/pp.bronaugh.htm>
7. <http://www.fcc.gov/eb/Orders/2007/DA-07-808A1.html>
8. Results of the 2007 CQ WW Foxhunting Weekend are in the May 2008 issue of *CQ* magazine, including a photo of this unusual twig-transmitter.
9. <http://www.147300.com/projects/tigertail.htm>

By Bob Witte,* KØNR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

How Many Decibels are in My S-meter?

Ever wonder how accurate the S-meter on your FM VHF transceiver really is? An S-unit equals 6 dB of signal change, but what is my meter really telling me? This time we'll take a look at the S-meter characteristics of some typical FM radios.

Signal Reports

Amateur radio operators like to give and receive signal reports as part of their normal operating procedure. On the HF bands, during the first or second transmission it is normal to hear an RST (Readability, Signal Strength, and Tone) report. ("Tone" is used only for CW and RTTY, so on phone we just give the RS report.) The signal strength ranges from S1 to S9, corresponding to the reading on the receiver's S-meter.

On FM VHF it is more common to hear a report in terms of receiver quieting. For example, a perfectly clear signal is "full quieting," referring to how a strong FM signal pushes the noise down to zero. If there is a little noise present in the signal, you might get a report of "90% quieting." A very noisy signal would be "50% quieting," meaning that the received signal is about half noise.

However, we do have S-meters on most FM VHF rigs that we use to check signal strength. Through our normal operating, we get to know the weak spots in repeater coverage and how low the meter can go before we start to drop out of the repeater. The same thing is true on simplex. If another station's signal is full scale, then you are likely to work him (or her) without any problem. If his signal barely moves the meter on your receiver, then you might have more trouble making the contact.

The Ideal S-meter

The ideal definition of the S-meter has the S9 level equal to –73 dBm or 50 µV. Each S unit corresponds to a 6-dB change in signal level. That is, a signal level of S8 should be 6 dB lower than S9, or a factor of 2 smaller in voltage (25 µV). Similarly, S7 should be another 6 dB smaller, or 12.5 µV. It is common for the S-meter to expand the scale to beyond S9, indicating "S9 + 20 dB" and "S9 + 40 dB." The entire scale of the ideal S-meter is shown in Table 1.

S-meter Specification

Meter Reading	dBm	µV
S9 + 60 dB	–13	50059.3
S9 + 40 dB	–33	5005.9
S9 + 20 dB	–53	500.6
S9	**–73**	**50.1**
S8	–79	25.1
S7	–85	12.6
S6	–91	6.30
S5	–97	3.16
S4	–103	1.58
S3	–109	0.79
S2	–115	0.40
S1	–121	0.20

Table 1. The definition of the ideal signal-strength meter (S-meter).

No S-meter hits this scale exactly, but I have noticed that most FM transceivers are way off the mark. Through casual usage, it appeared that these meters are no where near the "6 dB per S unit" standard. This caused me to take a deeper look into the typical S-meter on a representative sample of FM VHF rigs.

The first thing you notice on today's FM rigs is that they don't really have "meters" in the traditional analog sense. They have a signal-strength indicator, normally a bar graph, as part of their LCD display. These bar graphs may or may not have the specific "S units" shown on the scale. This might be a clue that they don't conform to the classic S-meter definition.

The first thing you notice on today's FM rigs is that they don't really have "meters" in the traditional analog sense.

Measurement Results

I rounded up a variety of FM transceivers that I had available and used an HP 8920A RF Communication Test Set to insert a known signal into the antenna port of the transceiver. The transceiver was tuned to 146.400 MHz with the squelch open. Starting at a very low signal level, I increased it until the first "bar" of the S-meter lit up reliably, and I recorded the signal level in µV. Then I increased the signal level until the next bar lit up and recorded that value. I repeated this procedure until the S-meter read full scale and I had signal levels recorded for each of the S-meter readings.

Table 2 shows the results for a Kenwood TM-231A 2-meter FM mobile transceiver. The meter is a bar graph with 14 individual segments, also labeled in S units (photo A). Because they turn on two at a time, these 14 bars really only have

TM-231A
S-meter Reading

No. of Bars	Label	Signal Level (µV)	Step Size (dB)	dB Relative to MDS (0.1 µV)
2	S1	0.26		8.3
4	S3	0.35	2.6	10.9
6	S5	0.49	2.9	13.8
8	S7	0.77	3.9	17.7
10	S9	2.84	11.3	29.1
12	Over	5.10	5.1	34.2
14	Over	8.77	4.7	38.9

Table 2. Measurement results for the Kenwood TM-231A transceiver.

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Photo A. The Kenwood TM-231A has a bar-graph display for the S-meter.

Photo B. The Yaesu FT-7800 has a bar graph without any labeling.

IC-2710
S-meter Reading

No. of Bars	Label	Signal Level (µV)	Step Size (dB)	dB Relative to MDS (0.1 µV)
2	S1	0.10	—	0.0
4	—	0.32	10.1	10.1
6	S5	0.49	3.7	13.8
8	—	0.70	3.1	16.9
10	S9	1.04	3.4	20.3
12	—	1.80	4.8	25.1
14	—	2.75	3.7	28.8

Table 3. Measurement results for the ICOM IC-2710 transceiver.

Decibels

The decibel is a convenient way of describing the ratio of two signal levels. The dB is defined as the ratio of two power levels, P1 and P2:

$G_{dB} = 10 \log_{10} (P_2 / P_1)$

For example, if P_1 =1 watt and P_2 = 2 watts, the ratio expressed in dB is:

$G_{dB} = 10 \log_{10} (2 / 1) = 3$ dB

We can say that P_2 is 3 dB larger than P_1, or we can say that P_1 is –3 dB relative to P_2.

For computing decibels for voltages, we can use this equation:

$G_{dB} = 20 \log_{10} (V_2 / V_1)$

which is valid for the case where the impedance is the same for both voltages.

For example, if V_2 is 5 volts and V_1 is 2 volts, the ratio expressed in dB is:

$G_{dB} = 20 \log_{10} (5 / 2) = 7.96$ dB

A factor of two change in power corresponds to 3 dB.
A factor of ten change in power corresponds to 10 dB.
A factor of two change in voltage corresponds to 6 dB.
A factor of ten change in voltage corresponds to 20 dB.

For more information on decibels see: <http://en.wikipedia.org/wiki/Decibel>.

seven different meter readings. The first two bars are labeled "S1" and activate at a signal level of 0.26 µV. The next two bars correspond to "S3" and turn on when the signal reaches 0.35 µV. Review the table for the rest of the meter readings.

The "Step Size" column shows the difference between the two adjacent meter readings in dB. For example, the S3 meter reading is 0.35 µV, which is 2.6 dB larger than the S1 meter reading of 0.26 µV. According to the labeling, this is a two S-unit change in signal level, so an ideal meter would indicate a 12 dB change. Examining the rest of the column, we see that the step size tends to be in the range of 2.6 dB to 5.1 dB, except for the large jump of 11.3 dB between the S7 and S9 level.

The right-most column shows the cumulative change in meter, shown in dB relative to the *minimum discernable signal* (MDS) level of 0.1 µV. (All of the transceivers tested had an MDS of roughly 0.1 µV, so that value was used for all calculations, just to keep it simple and consistent.) This column gives us an idea of the range of signals the S-meter can display. For the TM-231A, the meter hits full scale when the signal is 38.9 dB above the MDS.

I did the same measurements on the 2-meter receiver of an ICOM IC-2710 dualband transceiver (Table 3). Here we see the meter topping out at 28.8 dB above the MDS and having steps between meter readings average about 3 to 4 dB. Just like the TM-231A, this meter does not follow the ideal S-meter scale.

The Yaesu FT-7800 also has the bar-graph type S-meter, but without any labeling (photo B). This rig has nine distinct bars in the graph that turn on independently, giving nine distinct steps in meter reading. The step size between each meter reading varies from 2.6 dB to 4.8 dB, and full scale is about 35 dB above the MDS (Table 4).

Handheld Transceivers

I also measured a few handheld radios to see how they would compare. I have an older Kenwood TH-77A with an unlabeled bar graph as the S-meter. It has five bars on the graph with step sizes ranging from 4.9 dB to 6.7 dB. The meter hits full scale at a fairly low signal level (2 µV), which is 26 dB above the MDS (Table 5).

The Kenwood TH-79A handheld is slightly newer than the TH-77A, also

FT-7800
S-meter Reading

No. of Bars	Signal Level (μV)	Step Size (dB)	dB Relative to MDS (0.1 μV)
1	0.22	—	6.8
2	0.35	4.0	10.9
3	0.54	3.8	14.6
4	0.83	3.7	18.4
5	1.44	4.8	23.2
6	2.14	3.4	26.6
7	2.96	2.8	29.4
8	3.98	2.6	32.0
9	5.78	3.2	35.2

Table 4. Measurement results for the Yaesu FT-7800 transceiver.

TH-77A
S-meter Reading

No. of Bars	Signal Level (μV)	Step Size (dB)	dB Relative to MDS (0.1 μV)
2	0.16	—	4.1
4	0.28	4.9	8.9
6	0.51	5.2	14.2
8	1.10	6.7	20.8
10	2.00	5.2	26.0

Table 5. Measurement results for the Kenwood TH-77A handheld transceiver.

TH-79A
S-meter Reading

No. of Bars	Signal Level (μV)	Step Size (dB)	dB Relative to MDS (0.1 μV)
2	0.18	—	5.1
4	0.23	2.1	7.2
6	0.30	2.3	9.5
8	0.40	2.5	12.0
10	0.58	3.2	15.3

Table 6. Measurement results for the Kenwood TH-79A handheld transceiver.

with an unlabeled S-meter having five distinct readings. These readings have a fairly consistent spacing ranging from 2.1 to 3.2 dB, with full scale at 15 dB above the MDS (Table 6).

The Yaesu VX-2 handheld transceiver has a bar graph with eight unique readings (bars seven and eight are linked together) and is labeled at the S1, S5, and S9 levels (photo C). Except for the big 10 dB jump between the first two bars, the step size ranges from 3.1 to 4.8 dB, and the meter hits full scale at 32.6 dB above the MDS (Table 7).

All-Mode HF/VHF Transceiver Measurements

I wondered whether a more full-featured rig would have better S-meter performance, so I repeated the same measurements on a Yaesu FT-847. This is an all-mode rig with coverage of the HF bands, 6 meters, 2 meters, and 70 cm. The S-meter is implemented via the LCD display but with much finer resolution than the typical FM-only rig (30 bar segments in the meter). This meter is well-labeled with S1, S3, S5, S7, S9, S9+20 dB, S9+40 dB, and S9+60 dB (see photo D). Table 8 shows the results for this radio. All measurements were made at 146.400 MHz, for both the FM and SSB modes. In the FM mode, the S-meter has a step size that ranges from 3.1 to 4.4 dB. Actually, the meter resolution is much finer than this, but Table 8 shows only the S units labeled on the meter. Most of these "steps" are two S units, so 3 to 4 dB is much lower than the ideal 12-dB change. At the high end of the scale (S9+20 dB, S9+40 dB, and S9+60 dB), the steps should be 20 dB, so the meter comes up short there as well.

Now let's compare the SSB meter readings with the FM readings on the FT-847. Note that the resulting step size is considerably larger in SSB mode. Also, full scale for the meter tops out at 1.4 mV, also much larger than with the FM mode. The S-meter hits full scale in the FM mode at 44.8 dB above MDS, compared to 82.9 dB for the SSB mode. Clearly, the S-meter has a much wider range in the SSB mode than when operating FM. I had always suspected that the S-meter on this rig maxed out more quickly when running FM, so these measurements confirm that suspicion (Table 8).

Conclusions

First, let me be clear that I am not picking on these particular rigs or manufacturers. I happened to have easy access to this group of radios, so those are the ones I measured. I believe they are a representative sample of FM rigs in use on the VHF bands today. I don't really see any of them significantly better or worse with regard to S-meter performance, as they all come up short compared to the ideal meter.

Second, this article focuses on measuring FM VHF transceivers. Don't as-

Update on SERA D-STAR Band Planning

In the last issue of *CQ VHF*, I discussed the challenge of band planning to accommodate the new digital voice technologies, D-STAR and APCO Project 25. At the time, the Southeastern Repeater Association (SERA), the largest repeater coordination body in the U.S., was still studying the issue. In January 2008, the SERA board approved changes to the 2-meter and 70-cm bands.

On the 2-meter band, these new D-STAR channels are defined:

Repeater pairs (outputs/inputs)
144.920 / 147.420 MHz
144.940 / 147.440 MHz
144.960 / 147.460 MHz
144.980 / 147.480 MHz

145.020 / 146.420 MHz
145.040 / 146.440 MHz
145.060 / 146.460 MHz
145.080 / 146.480 MHz

On the 70-cm band, a 12.5-kHz channel spacing was adopted, interleaving D-STAR channels within existing 25-kHz channels.

More info visit <www.sera.org> or contact the appropriate frequency coordinator.

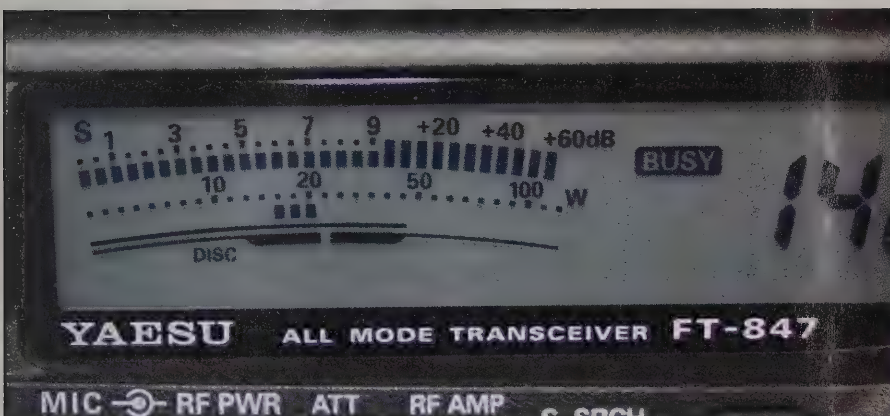
sume these results apply to your typical HF transceiver using CW or SSB.

Most of the radios tested have an S-meter that covers a range of about 30 to 40 dB. While falling short of the ideal S-meter characteristics, this is still a very useful measurement range. The low end of the meter range corresponds to the condition where the signal is very noisy and just barely readable. Thus, the typical meter allows us to track *relative* signal level above MDS. What the meter doesn't do is provide an *absolute* signal-strength reading. Clearly, we can't count on each S unit or bar corresponding to 6-dB steps (or any other calibrated step). These S-meters are a relative indication only. While giving us a good way to compare signals on the same radio, we can't conclude too much beyond that—that is, three bars on one radio may be totally different than three bars on another. Therefore, the next time someone tells you that your signal dropped by 6 dB (one S unit), you can believe that your signal dropped but you won't know for sure by how much.

In a future column I will provide some tips and techniques on how you can make more accurate measurements using these basic S-meters.

Photo C. The display of a Yaesu VX-2 handheld transceiver.

Photo D. The S-meter from the Yaesu FT-847 HF/VHF all-mode transceiver.



VX-2
S-meter Reading

No. of Bars	Label	Signal Level (µV)	Step Size (dB)	dB Relative to MDS (0.1 µV)
1	S1	0.10	—	0.0
2	—	0.32	10.1	10.1
3	—	0.49	3.7	13.8
4	—	0.70	3.1	16.9
5	S5	1.04	3.4	20.3
6	—	1.80	4.8	25.1
8	—	2.75	3.7	28.8
9	S9	4.27	3.8	32.6

Table 7. Measurement results for the Yaesu VX-2 handheld transceiver.

Tnx and 73

Thanks for taking the time to read another one of my columns on "FM, The Utility Mode." I always enjoy hearing from readers, so drop me an e-mail or stop by my weblog at: <http://www.k0nr.com/blog>.

Bob, KØNR

Reference

Wikipedia reference on S-meters: <http://en.wikipedia.org/wiki/S_meter>

FT-847 (FM Mode and SSB Mode)

S-meter Reading		FM	FM	FM	SSB	SSB	SSB
No. of Bars	**Label**	**Signal Level (µV)**	**Step Size (dB)**	**dB Relative to MDS (0.1 µV)**	**Signal Level (µV)**	**Step size (dB)**	**dB Relative to MDS (0.1 µV)**
3	S1	1.06	—	20.5	0.85	—	18.6
7	S3	1.53	3.2	23.7	1.56	5.3	23.9
11	S5	2.18	3.1	26.8	3.06	5.9	29.7
15	S7	3.26	3.5	30.3	7.20	7.4	37.1
19	S9	4.75	3.3	33.5	24.60	10.7	47.8
22	+20 dB	7.00	3.4	36.9	50.60	6.3	54.1
25	+40 dB	11.60	4.4	41.3	208.00	12.3	66.4
29	+60 dB	17.40	3.5	44.8	1400.00	16.6	82.9

Table 8. Measurement results for the Yaesu FT-847 HF/VHF/UHF transceiver.

By Mark Thompson, WB9QZB

DIGITAL RADIO

Digital Technology on VHF, UHF, and Microwaves

Digital Voice and Data Modes The Way Forward

I recently was recently asked by Joe Lynch, N6CL, the Editor of *CQ VHF* magazine, to do a column about digital technology on VHF, UHF, and the microwave bands. I have experience writing many editorials over the last 20 years for the "RAIN Report." I decided that with the help of the digital ham community there is an important role for this new column.

First, a little background about me: I was first licensed in 1975 in Wisconsin. I am an active ham who reads all of the ham radio publications and belongs to three radio clubs in the Chicago area. I also attend the Dayton Hamvention® every year.

I first became interested in digital technology in the late 1970s while a student at the University of Wisconsin, Madison. Our student ham radio club was given a Teletype Model 15 that we cleaned and adjusted. We got the loop current for the Model 15 from a Johnson T/R switch we were no longer using. We then acquired a HAL ST-5000 terminal unit that we used on both HF and 2-meter auto-start. The Model 15 handled only the Baudot format of RTTY.

In the mid 1980s I bought my first Kantronics TNC (terminal node controller) and became active in packet radio. I became involved with the Chicago Area Packet Radio Association (CAPRA) and I founded a separate packet radio frequency coordination group. CAPRA was a very active club and built many of the packet radio networks in the Chicago area in the 1990s. In 1998 Carl Bergstedt, K9VXW, and I, along with CAPRA, were the co-hosts for the ARRL/TAPR DCC (Digital Communications Conference) in Chicago. We will host the 2008 DCC in Chicago in September. There will be more about the DCC in a future column.

At the Dayton Hamvention® in 2004 and 2005, I noticed the new D-STAR digital voice and data technology at the ICOM booth. In early 2006 I became more interested in D-STAR. I educated myself about the technology and met and talked with hams who have been experimenting with and deploying the technology. Although I had given many presentations in my work, I had never given a presentation to a ham radio group. In spring 2006 I began to give D-STAR Introduction/Overview presentations at ham club meetings and hamfests in northern Illinois, southern Wisconsin, and northern Indiana. The presentations were well received, with large attendance. There is a great deal of interest in digital voice. During 1 1/2 years I have given over three dozen presentations and met many hams. In addition, I have been directly involved with the deployment of D-STAR technology in the Chicago area.

A year and a half ago I started a new Yahoo group focusing on digital voice and data technologies. Entitled the "illinoisdigitalham," the group has dozens of files and links covering all the digital ham modes and now has approximately 2400 members. More information on the group can be found at: <http://groups.yahoo.com/group/illinoisdigitalham>. As its moderator, it has given me exposure to many digital technologies and different points of view.

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History of Digital Modes

For most of the history of ham radio digital has meant data. RTTY Baudot and then RTTY ASCII were the mainstay of digital until AX.25 packet radio was developed in the early 1980s. The packet radio TNC (terminal node controllers) led to multi-mode controllers that could handle CW, packet, AMTOR, RTTY, and other modes.

These multi-mode controllers were quite popular until the sound-card modes such as PSK, MFSK, Olivia, etc., were developed. Sound-card modes run on any Windows® PC using the PC's sound-card and require an interface to the radio. Several firms have developed interface units to allow connection to the radio with the correct cable. Both packet radio and the sound-card modes are backward compatible with existing analog radios in that they operate on FM and SSB radios. Sound-card modes can transmit and receive both voice and data.

They used to tell us that CW got through when nothing else could. Then they invented narrow-band data modes such as PSK, which gets through at barely detectible signal levels. Other weak-signal data modes have been developed for meteor-scatter use. These modes prove digital data can bring new capabilities to ham radio. There are now several different digital data modes, each of which has distinct advantages, disadvantages, and applications for use. One of the most popular is WSJT, which was developed by Joe Taylor, K1JT. More on WSJT can be found at: <http://physics.princeton.edu/pulsar/K1JT>.

Some hams have been experimenting and using high-speed data called HSMM, High Speed Multi Media. In some cases HSMM has been implemented using off-the-shelf Wi Fi technology. D-STAR has a high-speed data capability on 1.2 GHz utilizing a data access point allowing connectivity to internet or intranet resources.

Digital Voice

In most sectors of commercial communications technology—from public safety two-way radio to cellular phones to broadcasting digital technology—digital is the future. The conversion from analog to digital if not complete, is well under way.

Ham radio voice traditionally has been an analog technology, but over the last few years it has started to change. Implementing digital voice on VHF and UHF is reasonably straightforward, but implementing digital voice on HF poses several more significant challenges,

including multi-path, fading, QRM, and QRN. Digital data on HF faces some of these same challenges, but due to its typically narrow bandwidth the problems in many cases are not as significant. HF digital voice has been implemented using either a separate device or PC sound-card modes, such as WINDRM or FDMDV, attached through an interface to a traditional analog radio. This same approach could be used on VHF and UHF SSB.

In 2007 the ARRL conducted an RFI (Request For Information) to learn what ham radio operators wanted in an open-source digital voice protocol. The results were presented at the ARRL/TAPR DCC in September in Hartford, Connecticut. I hope to review those findings in a future column.

Digital voice on VHF, UHF, and the microwaves so far has taken two similar, but different approaches—Project 25, more commonly known as P25, and D-STAR. P25 is an open standard developed by APCO, an association of public safety professionals. P25 radios are commercial grade and can be expensive if new. They typically need special software and interface cable to program them.

D-STAR is an open protocol defined by the JARL (Japan Amateur Radio League). D-STAR digital voice radios are capable of both digital voice and concurrent low-speed data, as well as traditional analog FM. In addition, on 1.2 GHz there is a separate high-speed data (128 KB) capability. Built into D-STAR technology is the ability to interconnect D-STAR repeaters seamlessly to the internet using a D-STAR internet gateway PC. While ICOM is the only commercial manufacturer making radios for D-STAR at this time, other manufacturers can utilize the standard. A new product, the DV Dongle, has been developed by Robin, AA4RC. The Dongle plugs into the USB port of a PC and allows voice calls over the internet to D-STAR repeaters with gateways running the dplus software.

Two advantages of digital voice are: the bandwidth is significantly narrower than analog FM; and there is greater effective range because of the lack of path noise as the signal becomes weaker, making weak digital voice signals more readable. I have found that many hams are under the mistaken impression that under weak-signal conditions digital voice will be garbled and less intelligible than analog voice. It appears this impression has been gained due to digital cellular phones becoming garbled when the signal is weak. However, since you can't switch to FM at the same power level while making a cell call, there is no real basis for this assumption other than the observation that digital gets garbled when weak.

There is a recording available at the illinoisdigitalham group that dramatically demonstrates the difference between digital voice and analog FM under weak-signal conditions. Also available is a white paper in which Motorola has articulated the technical reasons for this dramatic difference. In order to access these one must join the group. Visit the digital ham group at: <http://www.yahoogroups.com/illinoisdigitalham> to join the group and learn more about the ham digital voice and data modes.

The Future of Digital Ham Radio

We are in the infancy of the implementation of digital voice and data in ham radio. From spark to CW, AM to SSB on HF, AM to FM on VHF, hams historically have embraced new technology. I believe it is critical to amateur radio that we embrace digital technology to keep us in the forefront of technology. There are very legitimate reasons to use digital technology, since it brings capabilities unavailable using traditional analog technology. It is the goal of this column to explore those new technologies and the new applications that use them.

Your Digital Column

I want this column to be *your* column. There are many of you who have extensive knowledge of many of the digital modes. I plan to include your experiences with digital voice and data in this column. Please e-mail me your thoughts and ideas regarding the topics you would like covered and how you might contribute your knowledge and expertise.

73, Mark, WB9QZB

Belgian Satellite Features D-STAR Technology

Students at the Universite de Liege in Belgium have built OUFTI-1 <http://www.leodium. ulg.ac.be/cmsms/>, a new amateur radio CubeSat featuring D-STAR digital-communication protocol that is used for control and telemetry. Amateur radio operators from all over the world are able to listen in on the ONØULG D-STAR repeater on 70 cm <http://www.jfindu.net/dstarlh.aspx?rptr=ON0ULG>. On 70 cm the output frequency is 439.525 MHz, and they are using a 7.6-MHz shift. By the time you read this, 2 meters should be operational.

The objective of this nanosatellite project is to provide hands-on experience to students in the design, construction, and control of complete satellite systems that will ultimately serve as the basis for a variety of space experiments. The first satellite in the series is a CubeSat, which is a cube with dimensions of 10 × 10 × 10 cm and a weight of at most one kilogram.

The key innovative feature of OUFTI-1 is the use of the D-STAR amateur-radio digital-communication protocol. This means of radio communication will be used for control and telemetry, and will be made available to ham radio operators worldwide. In the future, it will also be used to control space experiments.

This project is a student project. Students thus are encouraged to join the project. Please contact Gaetan Kerschen at <g.kerschen@ulg.ac.be> or Jacques Verly at <Jacques.verly@ulg.ac.be> for further information. Portions of this report previously appeared in the April 4, 2008 *ARRL Letter.*

By Miguel Enriquez,* KD7RPP

Amateur Television in Math and Science Curricula

Pueblo Magnet High School is located in the most socially and economically depressed area of Tucson, Arizona. The daily challenges the students face at the school are many of the same trials and tribulations found in many other high schools in this nation—drugs, violence, low achievement scores, and a high dropout rate. Early in the 2005–2006 school year I started an amateur radio club at Pueblo Magnet High School. I had tried other approaches to bring life into the math classes I was teaching, but had been unsuccessful in getting the students' attention or their participation.

As I was teaching a class in August 2005, my handie-talkie went off. Through the magic of one of the local repeaters, my students heard the caller identify her location as Show Low, Arizona. The students stopped listening to my lecture and they began to pay attention to the friendly voices on the radio.

Taking advantage of the unexpected teaching moment, I held up the radio in order to improve the signal reception so that the students could better understand the conversation taking place. The effect this QSO had on the students was priceless. Right away they wanted to know why my cell phone looked "funny" with the strange antenna. They next wanted to know why I was listening to the conversation when it obviously was not intended for me. They next speculated that perhaps I was a spy working for the CIA.

After I had explained to them that ham radio is probably the best hobby in the world because it allows any one of us to communicate with practically anyone else on the face of the Earth or onboard the International Space Station (ISS), their first two questions were: "Where is Show Low?" and "What is the International Space Station?" This magnificent opportunity demonstrated that I now had their attention, their curiosity was piqued, and they were participating!

From that day on, I began to talk about ham radio as part of the math curriculum. By the end of that first week I had students asking me how they could become radio hams. Next, I began talking about electrons, frequencies, resistors, and bands. They paid attention.

Now it is important to share with you that I am neither a religious person nor a person who expects miracles of any kind. Even so, somehow, for some unknown reason, the students began to perform better in their daily math assignments and in their exams. Bear in mind that 94% of my students are Hispanic and that many of them struggle to learn even the most basic concepts. However, my math students now show the highest benchmark scores in algebra in the school district.

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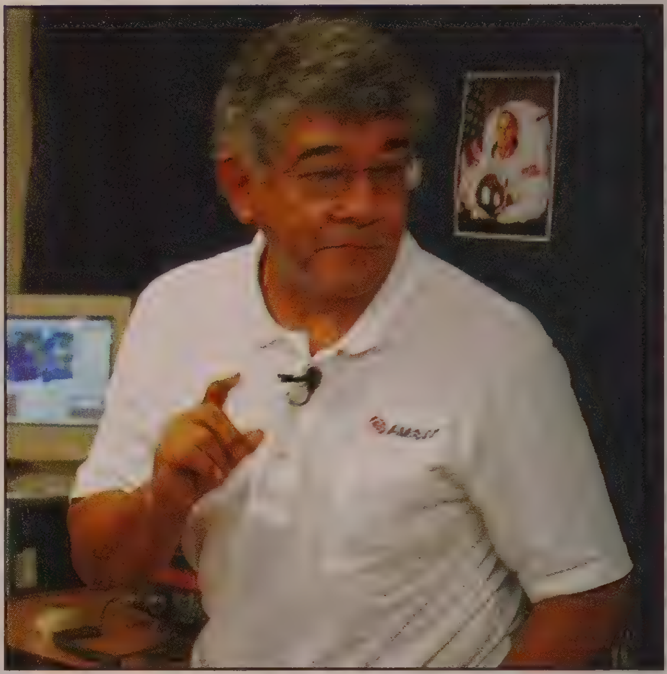
e-mail: <miguel.enriquez@tusd1.org>



Miguel Enriquez, KD7RPP, is a mathematics teacher at Pueblo Magnet High School in Tucson, Arizona. He is using ATV to create enthusiasm among his students for their studies and amateur radio.

In September 2006, another "miracle" came our way. ARRL Education and Technology Program Coordinator Mark Spencer, WA8SME, sent an e-mail announcing that Ms. Anoushe Ansari, the civilian astronaut onboard the ISS, would make contact with a few interested schools. I replied indicating our interest, and within hours we were scheduled for a QSO with the ISS the following morning.

With less than 18 hours to prepare, the students and I set about putting together the best radio shack we could afford. The following morning, with local broadcast media reporting our QSO, we were able to hear the call from RØISS, but our 5-watt FT-817 and a fellow math teacher on the rooftop tracking the ISS with a hand-held Yagi antenna failed to confirm the QSO.

Our near-QSO proved to be a blessing in disguise. I began explaining the mechanics necessary to accomplish this feat as part of the math instruction I was providing. The students resolved to earn their ham tickets and to work to put together a team that would successfully communicate with the ISS. The following spring five students earned their Technician tickets,

and a month later one of those students upgraded to General class. Thanks again to the support of Mark Spencer and the ARRL, as well as local Elmers, we successfully communicated with Astronaut Clayton Anderson, KD5PLA, onboard the ISS on September 21, 2007. The entire QSO is available at: <http://youtube.com/pueblowarriorsarc>.

Along the way, another "miracle" came our way. That miracle is Ron Phillips, AE6QU. Ron replied to an e-mail I sent requesting Elmer support for our club. In November 2006 Ron called me to offer support and to introduce Amateur Television (ATV) to us. Since then Ron and Mike Collis, WA6SVT, have contributed their time and equipment to create an ATV station at our school, and our students have learned to operate the equipment. They have constructed antennas and other electronic ATV equipment, as well.

Our students now make presentations to other schools in Tucson to promote ham radio and ATV. They are also taking electronics classes and are learning to construct and program robotic equipment. Furthermore, they are actively applying the knowledge they receive in their science, mathematics, geography, electronics, and communications classes.

All of this explanation of our school's ham radio program brings me to the purpose of this column: Ron, AE6QU, and I have committed to writing a column for *CQ VHF* magazine to introduce and promote Amateur Television. We intend to provide information such that other school clubs can better understand and begin to use this magnificent technology. We will dispel the many myths held among ham operators about ATV and provide simple "how to" steps to get clubs to easily join the fun of ATV. We also will develop video demonstrations performed by our students at Pueblo that you, the reader, will be able to use to instruct interested students in your schools and communities.

A wise person once said that to make this a better world one only needs to care for and to contribute something positive to friend and stranger alike. To our present friends, we wish to contribute our knowledge of and passion for ATV, and to those of you who presently are strangers to us, we wish to make you our friends by providing meaningful presentations that will add to your enjoyment of the airways.

73 de Miguel, KD7RPP

By Tomas Hood,* NW7US

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

A Switch is Thrown

As we move into May, short-distance (only short when compared to long-haul DX of thousands of miles often experienced in the high-frequency spectrum) propagation opens up in the VHF, and sometimes UHF, spectrum. These openings provide propagation of radio signals for hundreds of miles and occur almost as if a switch has been turned on. This is a mostly summer-time phenomenon called *sporadic-E*.

Sporadic-*E* (E_s) is the term given to the mode of propagation in which clouds of highly dense ionization develop in the *E* layer of the ionosphere. These clouds might be very small, but regardless of their size, they seem to drift and move about, making the propagation off these clouds short and unpredictable. It is well documented that E_s occurs most often in the summer, with a secondary peak in the winter. These peaks are centered very close to the solstices. The winter peak can be characterized as being five to eight times less than the summer E_s peak.

Ten-meter operators have known E_s propagation as the summertime "short skip." These "clouds" appear unpredictably, but they are most common over North America during the daylight hours of late spring and summer. E_s events may last for just a few minutes up to several hours and usually provide an opening to a very small area of the country at any one particular time.

During periods of intense and widespread E_s ionization, two-hop openings considerably beyond 1400 miles should be possible on 6 meters. Short-skip openings between about 1200 and 1400 miles may also be possible on 2 meters.

Scientists are still pursuing the multiple causes of sporadic-*E*. As far back as 1959, ten distinct types of sporadic-*E* and at least nine different theories of causation were offered. The classification of distinct types has been retained, but since the 1960s the wind-shear theory has become one of the most accepted theories.

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Wind shearing occurs when the wind blows at different directions and speeds as you increase with height. Simply, the wind-shear theory holds that gaseous ions in the *E* layer accumulate and are concentrated into small, thin, patchy sheets by the combined actions of high-altitude winds and the Earth's magnetic field. The resulting clouds may attain the required ion density to serve as a reflecting medium for VHF radio waves. Although most research has confirmed a close association between wind shear and sporadic-*E*, not all aspects of the sporadic-*E* phenomenon can be explained, including its diurnal and seasonal variations.

How can we know when a sporadic-*E* opening is occurring? Several e-mail reflectors have been created to provide an alerting service. One is found at <http://www.gooddx.net/> and another at <http:/www.vhfdx.net/sendspots/>. These sporadic-*E* alerting services rely on live reports of current activity on VHF. When you begin hearing an opening, you send out details so that everyone on the distribution list will be alerted that something is happening. They, in turn, join in on the opening, making for a high level of participation. Of course, the greater the number of operators on the air, the more we learn the extent and intensity of the opening. The bottom line is that you cannot work sporadic-*E* if you are not on the air when it occurs.

Speaking of being on the air, check out PropNET on 6 meters. This network of stations monitors the current propagation occurring on a given band, such as 6 meters, in an active way. Rather than just listening for stations, each station sends a beacon that allows the other participating stations to "catch" the beacon and then report the reception in real-time to a map that plots all of the paths that have been "caught." By participating, you add to the working, real-time knowledge of the band's conditions. PropNET is located at <http://superdarn.jhuapl.edu/>.

In addition to live reporting, there is a very powerful resource available on the internet. Check out <http://superdarn.jhuapl.edu/>. SuperDARN (Super Dual Auroral Radar Network) is an international radar network for studying the Earth's upper atmosphere and ionosphere. Using the SuperDARN real-time data 24-hour overview, you can view the day's ionization activity at the northern polar region. You may also view live radar displays of the same area. These graphs help identify E_s clouds that exist in the higher latitudes. One use for this would be the detection of a variation of E_s, known as auroral-*E*.

For a great introduction on mid-latitude sporadic-*E* propagation, visit the AM-FM DX Resource website <http://www.amfmdx.net/propagation/Es.html>.

Tropospheric Ducting

Most propagation on VHF and above occurs in the troposphere. There are a number of well-documented modes of tropospheric propagation. The most common is line-of-sight propagation, which can, depending on the height of the transmitting and the receiving antennas, extend to about 25 miles. When you work simplex FM or FM repeaters in your local area, you are hearing typical line-of-sight tropospheric propagation.

Another possible mode of propagation is by tropospheric ducting. The term *tropospheric ducting* refers to the stratification of the air within the troposphere.

The Troposphere

The troposphere is the lowest layer of our atmosphere, bounded below by the Earth's surface and above by the tropopause. It extends from the Earth's surface to a height of slightly over seven miles. Almost all weather phenomena occur in this region.

The troposphere is divided into two layers: the lower troposphere, which extends up to about two miles above the Earth's surface; and the middle and upper troposphere, ranging from 2 miles up to the tropopause at 8 to 12 miles above the surface of the Earth.

The lower layer of the troposphere can

contain ducts created by inversion layers and is the most common location for convective cells formed from solar warming of the ground and the atmosphere immediately above it. This contains most of our everyday weather and is by far the most active layer, in which changes in the radio refractive index are greatest.

The higher layer of the troposphere has less turbulence, so it is less useful in scatter propagation. Any ducts that form in the upper layer of the troposphere cannot normally be used for radio-wave propagation, except from aerial antennas, as the radio waves enter the ducts at too great an angle to be retained within them, but simply pass through.

Under perfect conditions, the troposphere is characterized by a steady decrease in both temperature and pressure as height above the Earth increases. However, the many changes in weather phenomena cause variations in humidity and an uneven heating of the Earth's surface. As a result, the air in the troposphere is in constant motion, causing small turbulences to form.

These turbulences, or eddies, are most intense near the Earth's surface and gradually diminish with height. They have a refractive quality that permits the refracting or scattering of radio waves with short wavelengths. This scattering is what provides enhanced communications at VHF and higher frequencies.

In the relationship between frequency and wavelength, wavelength decreases as frequency increases and vice versa. Radio waves of frequencies below 30 MHz have wavelengths longer than the size of normal weather eddies. HF radio waves therefore are affected very little by tropospheric turbulences. On the other hand, as the frequency increases into the VHF range, the wavelengths decrease in size. If the wavelength is small enough, it becomes subject to tropospheric scattering. The most usable frequency range for tropospheric scattering is from about 100 MHz to 10 GHz.

Above the tropopause, changes in temperature and water content are very small indeed, resulting in very little alteration in radio refractive index. Therefore, there can be little scatter or refraction, and no real assistance to propagation until the *E* layer and meteor trails are attained—above 60 miles or so.

When layers form within this region of air, the refractive index between each layer causes a refraction of VHF and UHF radio waves. If the layers form in just the right way and at the right height, a natural wave-guide is created. A tropospheric duct develops. A VHF signal can be ducted hundreds, if not thousands, of miles. It is common for Californian stations to work Hawaiian stations during tropospheric ducting between the islands and the U.S. mainland.

Scattered reports of some very strong tropospheric openings have been made during April (corresponding to severe spring weather), but typically we don't see widespread tropospheric ducting until summer. With the early reports, though, it is worth watching for this mode of propagation. The spring weather may well be violent and eventful this year, as has already been the case.

Advanced visual and infrared weather maps can be a real aid in detecting the undisturbed low clouds between the West Coast and Hawaii or farther during periods of intense subsidence-inversion band openings. This condition occurs also over the Atlantic. There is a great resource on the internet that provides a look into current conditions. Bill Hepburn has created forecast maps and presents them at <http://www.dxinfocentre.com/tropo.html>, which includes maps for the Pacific, Atlantic, and other regions.

If you know that conditions are favorable for tropospheric ducting in your area, try tuning around the 162-MHz weather channels to see if you can hear stations way beyond your normal line-of-sight reception. It is possible to hear stations over 800 miles away. Amateur radio repeaters are another source of DX that you might hear from the other end of the duct.

These openings can last for several days, and signals will remain stable and strong for long periods during the opening. However, the duct may move slowly, causing you to hear one signal quite well for a few hours, to then have it fade out and another station take its place from another area altogether.

Meteor Showers

The *Eta Aquarids* meteor shower will occur in May. The *Eta Aquarids* will peak the morning of May 6, but start at around April 21. This shower is expected to have a peak rate of up to 30 per hour this year. It is expected that this shower will have a broad period of maximum activity, starting as early as May 3 and extending out to May 10. Also, because of the low radiant, the meteors tend to have long ion-

ized paths, making for strong signal reflections. Look for 6- and 2-meter openings off the ionized meteor trails.

June has a possible strong shower, the *Boötids*. This shower is active from June 26 through July 2, with the peak occurring on June 27. The hourly visual rate can reach as high as 100 or more. The source of the *Boötids* is periodic comet 7P/Pons-Winnecke. *Boötid* meteoroids hit the Earth's atmosphere with a velocity of 18 km/s (40,000 mph). They are considered slow-moving meteors, making for strong VHF signal reflections off the plasma trails of the burning-up debris.

July has only minor showers. These showers typically have not yielded much radio activity. For more information on these, take a look at <http://www.imo.net/calendar/2008/>.

TE Propagation

A seasonal decline in TE (transequatorial) propagation is expected during May. An occasional opening may still be possible on VHF. The best time to check for VHF TE openings is between 9 and 11 PM local daylight time. These TE openings will be north-south paths that cross the geomagnetic equator at an approximate right angle.

The Solar Cycle Pulse

The observed sunspot numbers from January through March 2008 are 3.4, 2.1, and 9.3, respectively. The smoothed sunspot count for July 2007 was 7.0 and for August it was 6.1. September's smoothed sunspot count was not published as of the writing of this column.

The monthly 10.7-cm (preliminary) numbers from January and February 2008 are 72.1, and 71.2. The smoothed 10.7-cm radio flux for July and August 2007 are 72.5, and 71.8, respectively. The figures for March 2008 and September 2007 were not yet published at the time of this writing.

The smoothed planetary *A* index (*Ap*) numbers for July and August 2007 are 7.4 and 7.6. The monthly readings for January and February 2008 are 6 and 9. Again, the figures for March and September were not yet published.

The monthly smoothed sunspot numbers forecast for May through July 2008 are 4.8, 5.2, and 5.8. By this forecast, it looks like we are at the very beginning of the new solar Cycle 24. The smoothed monthly 10.7-cm numbers are predicted to be 63.1, 62.8, and 62.5 for the same months. If we consider these numbers, we see that cycle 24 is upon us. Give or take about 12 points for all predictions.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter, etc.). I'll create summaries and share them with the readership. I look forward to hearing from you.

Up-to-date propagation information can be found at my propagation center, <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing!

73 de Tomas, NW7US

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Near Space Workshop

I recently had the pleasure of teaching a two-day workshop at Purdue University's Columbus, Indiana campus, showing students how to design experiments for high-altitude balloon flights. Organized by Brian Tanner from TMG Labs of Carmel, Indiana and Assistant Professor Margaret Ratcliff from Purdue University, the workshop was made possible with funding by the NASA Indiana Space Grant Consortium.

We had nearly a dozen students in attendance for this session, ranging from middle school to college age, including a mom and her three home-schooled children who saw the event posted in the local paper. Everyone seemed fascinated by how inexpensively they could explore the very edge of space, and I could see science fair possibilities churning in their minds.

Keeping students of such a wide age range interested proved to be a challenge, but this was easily solved by some quick shopping at the local grocery store. Since it was near Easter, I stocked up on some multi-colored Easter Peep candies and some plastic eggs and told them we were going to send Peeps into space. I put the younger students to work designing space capsules to study the effects of heat and the vacuum of near space on their "Peep-o-nauts."

The older students were happily engaged in programming film and video cameras, installing dataloggers, setting up amateur radio GPS trackers, and stuffing it all into their Styrofoam payloads (photo 1). I discovered that mechanical engineering students actually carry most of their tools with them at all times, as we shortly had a room full of drills, saws, and wrenches, most of which were carried in their coat pockets.

Photo 1. Workshop payloads ready for takeoff. Left to right: Susahnah Beardall, Jackie Beardall, Bill Brown WB8ELK, Brian Tanner, Martin Baier, Dyllin Kinman, and Andrew Kinman. (Photos courtesy of the author unless otherwise noted)

Near Space Photography

We flew three RCA Small Wonder video cameras and in addition, four Canon

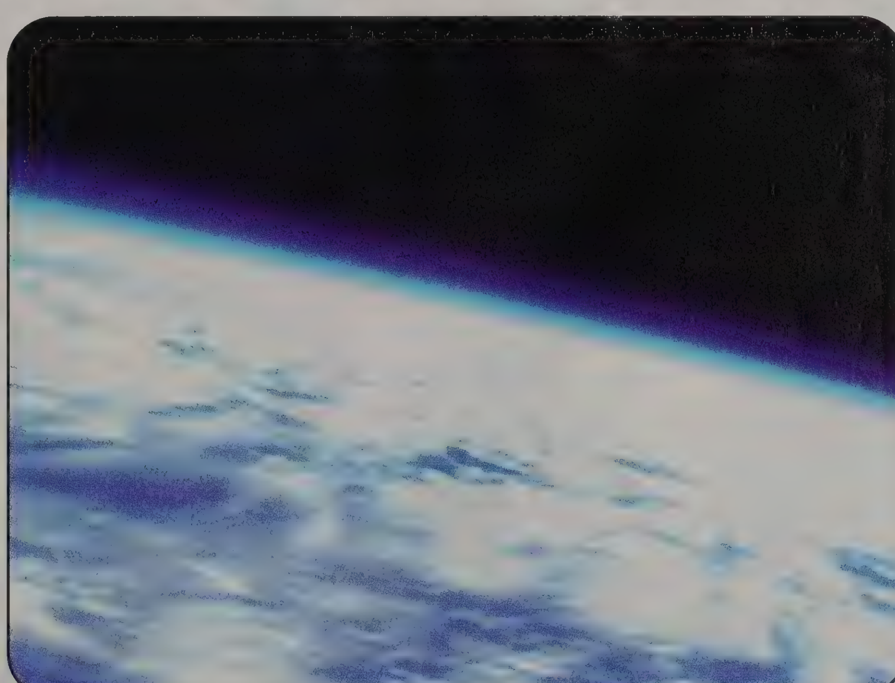

Photo 2. This photo was taken at 98,000 feet by our Canon A570IS running the CHDK BASIC script. (Photo courtesy of TMG Labs, <www.tmglabs.com>)

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e-mail: <wb8elk@aol.com>

Photo 3. The Balloon Workshop participants at the launch site.

A560 and A570IS digital still cameras pointing up, down, and at the horizon (photo 2). The neat thing about the Canon series is that a few folks have come up with BASIC programmable scripts that you put onto the camera's removable memory card and they program your camera to do timed interval shots and can control just about every feature of the camera. We set up our cameras to take a still picture every 30 seconds for the entire duration of the flight. This camera hack is called CHDK (http://chdk.wikia.com/wiki/Main_Page) and can be used with a wide variety of Canon digital cameras. Rick von Glahn, NØKKZ, of the Edge of Space Sciences balloon group, has an excellent web page and video clip showing exactly how to program the Canon A570IS, which includes his program to automatically control the camera for balloon flights (http://www.eoss.org/hardware/canon_a570is.htm).

On Saturday, March 1st, we took everything to the nearby Columbus airport to fly it all to the edge of space (photo 3). Site of the future Space Port Indiana (www.spaceportindiana.com), the airport handled the NOTAM filing as well as the tower communications to coordinate our liftoff. Since it was a bit windy and chilly, it was nice to have access to a large building with high ceilings for the balloon inflation (photo 4).

We had a perfect liftoff and watched the balloon head on its way into the stratosphere. In addition to the two APRS trackers (WB8ELK-11 and WB8ELK-12 using Byonics Microtrak 300s with Garmin GPS18-LVC GPS receivers), we also had a voice beacon on 147.42 MHz and a simplex repeater on 144.34 MHz FM. The simplex repeater was a Radio Shack simplex voice repeater module hooked up to an Alinco DJ-S11T HT. Note, however, that the Radio Shack simplex repeater module has been discontinued, but can often be found on eBay or at hamfests. The voice beacon was the Doppler DF systems very tiny Squawkbox circuit (photo 5) which sends out a voice message every 15 seconds (http://www.silcom.com/~pelican2/PicoDopp/MICROHUNT.htm).

The simplex repeater worked great, and we shortly had Bob, KA9UVY, in Mt. Vernon, Illinois and Mel, KA8LWR, in Bucyrus, Ohio talking with one another and with our ground control station in Indiana. At 98,000 feet, the repeater allowed stations in an eight-state region of the Midwest to talk with each other.

After its trip to over 98,000 feet, the payloads parachuted back to Earth and landed next to a small barn near Lexington, Kentucky. When I recovered the payloads, it was discovered that aliens had abducted the Peep-o-nauts during their trip into near space. It's hoped that someday they'll find their way back to Earth.

The students had a great time with the flight, and several are planning their own experiments with small balloons and even solar balloons for their school science projects. They also learned a valuable lesson: "Real science is not possible without duct tape."

Photo 4. Grant Ratcliff holds the balloon just prior to launch.

FindMeSpot GPS Tracker

APRS transmitters have made amateur radio high-altitude ballooning experiments easy to track, but they sometimes fail in flight or often land in an area beyond digipeater coverage.

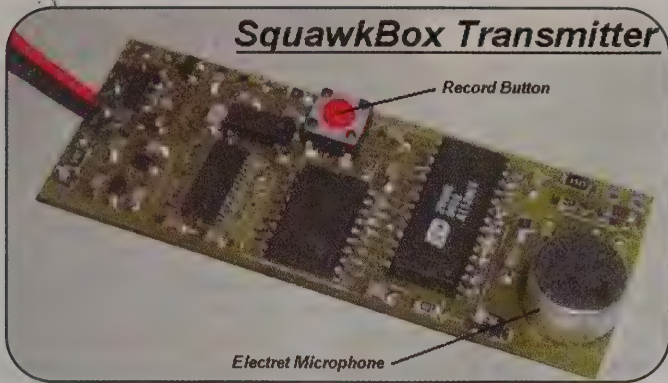

Photo 5. The Dopper DF Systems Squawkbox 50-milliwatt transmitter.

I've been on the search for a decently priced satellite GPS tracker for balloons for years.

Finally, the inexpensive FindMeSpot unit appeared on the market this past fall (www.FindMeSpot.com). At $169.99, this lightweight unit will directly uplink your GPS position to the orbiting GlobalStar network every 10 minutes for 24 hours. You do have to subscribe to the service for $149 a year ($99 basic service plus $49 continuous-tracking option), but it allows unlimited use with no additional fees. Compared with the exorbitant costs of other satellite modem systems and their connection fees, this is an amazing deal. Nearly world-wide coverage is promised, and as long as you don't land inside a cave, you'll be able to transmit your location up to the satellite network and have it displayed in near real time on a website Google map. We flew this on the Indiana Workshop balloon with great results.

Although the internal GPS receiver stops reporting above 60,000 feet, it does come back to life again during the descent below that altitude. Since both of our amateur radio APRS trackers failed during the flight (one with a broken antenna and one abducted by the aliens along with the Peep-o-nauts), we had to rely solely on the FindMeSpot satellite tracker (photo 6). It really saved the day, since it reported the final landing site within minutes of hitting the ground. When I recovered the payloads, I found that the FindMeSpot was actually upside down on the ground and still able to track its position and send messages to the satellites. When flying expensive balloon payloads, this has proven to be an invaluable backup tracker. It also is a good item to carry along with you when hiking in the woods for balloon recovery, since you can hit a "911" button that will get search-and-rescue services on the way in case of an emergency.

Dayton Hamvention® Ballooning Forum

This year there will be a Ballooning Forum at the Dayton Hamvention® on Friday, May 16th, at 1:15 PM. Speakers from several balloon groups from across the nation will talk about transatlantic crossing attempts, lightweight HF telemetry transmitter design, and a variety of amateur radio balloon-related topics. It should be great fun and I hope to see you there.

73, Bill, WB8ELK

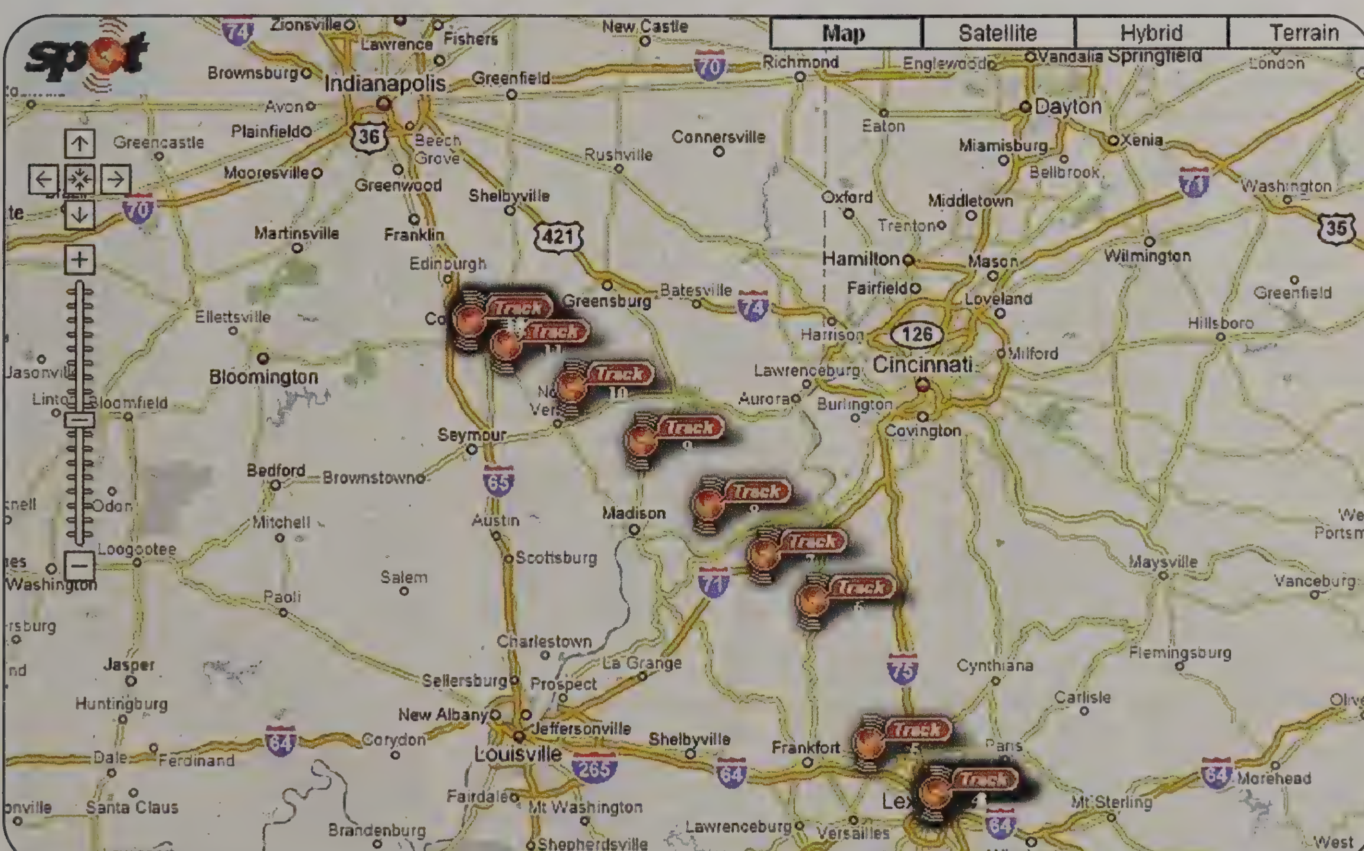

Photo 6. Flight-path track of the balloon using the FindMeSpot satellite tracker.

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

Lunar Link Analysis

In the previous Orbital Classroom column in the Winter 2008 issue of *CQ VHF,* we introduced the European and American Student Moon Orbiter initiatives (ESMO and ASMO, respectively), and mentioned that AMSAT may well have a role to play in their comm link and Earth station design. This time we will create a straw-man system specification for a reliable digital link to cover lunar distances, and discuss the antenna requirements for a capable command station. It should be noted that this column does *not* constitute an actual design proposal. Rather, it is my intent to show, by hypothetical example, the kinds of considerations that the ESMO and ASMO student designers (and their faculty advisors) will need to address in developing their own proposals.

The primary driver for any space communications link design is the power budget on the spacecraft itself. We consider the downlink to be limiting, in that the spacecraft's power budget is finite. (We can assume that the power available on Earth for uplink transmissions is virtually unlimited.) For solar-powered spacecraft, the power budget is, in turn, limited primarily by the spacecraft's mass and physical dimensions. For the present study, we will make the conservative assumption that the power budget will be no greater than that available on a standard university CubeSat.[1] The typical 10-cm cube of 1-kg mass, with high efficiency photocells covering six sides of the cube, readily produces (when in sunlight) at least 1 watt (+30 dBi) of continuous-wave RF output in any one of the popular 145-, 435-, or 2400-MHz downlink frequencies common in the Amateur Satellite Service.

For the sake of this analysis, let's assume our downlink will operate at UHF, in the 435-MHz band. We will further stipulate that the spacecraft lacks attitude control; hence we will require an omnidirectional downlink antenna. Because it would be easy to stow and deploy, it is common practice to equip CubeSats with a Vee dipole for UHF uplink or downlink. Such an antenna can be assumed to exhibit a gain on the order of +2.2 dBi, yielding an Effective Isotropic Radiated Power (EIRP) of +32.2 dBm.

Let's approximate the mean distance between the Earth and the Moon as 400,000 km. Over this distance, isotropic free-space path loss at a wavelength of 70 cm is on the order of 197.3 dB. Subtracting this loss from the spacecraft's downlink EIRP, we see that the isotropic power incident upon the Earth will be on the order of –165 dBm. This is a weak signal to be sure, which will require substantial antenna gain to pull out of the noise.

Figure our ground station is going to be built around a large, fully steerable parabolic dish. Obviously, the larger the dish, the more gain the antenna exhibits, and the more downlink signal is recovered at Earth. However, bigger is not necessarily better. The higher the gain of any antenna, the narrower its beamwidth will be and the harder it will be to aim and track. Remember that the spacecraft is going to be orbiting the Moon and is a vanishingly small target. A ground-station antenna with beamwidth sufficient to cover the entire lunar neighborhood will certainly simplify matters by lessening demands on the dish's tracking hardware and software. Also, a little extra beamwidth will allow us a little slop in ground-station operations, albeit at the cost of a bit of gain. Viewed from Earth, the Moon subtends 1/2 degree in the sky. Let's say we're going to make our antenna beamwidth 2 degrees so that when we point it at the moon, given even a 1-degree pointing error, the satellite's signals will still be captured.

OK, beamwidth in radians equals the diameter of the dish, measured in wavelengths. Two degrees equates to just under 40 milliradians, so our required antenna diameter will be (1/.04), or 25 wavelengths. Operating in the 70-cm band, this dish will have a required diameter on the order of 18 meters.

Is an 18-meter dish even feasible, let alone available? As a matter of fact, yes, and quite a few dishes of this general magnitude potentially are within our grasp. In Bochum, Germany, for example, AMSAT-DL has not only succeeded in renovating a 20-meter parabolic antenna, but has successfully recovered signals from both the ESA's Mars Express probe, and NASA's Voyager 1 interplanetary probe, now beyond the edge of our solar system. Closer to home, on Table Mountain near Longmont, Colorado, another amateur group, the Deep Space Exploration Society (DSES), has been refurbishing a pair of 18-meter dishes on a 61-meter baseline for both radio-astronomical research and possible CubeSat command and control. Similar dishes exist in several other locations, leading me to speculate that when the time comes, partnerships can be forged and collaborations set up, enabling us to secure the use of appropriate instruments to command and control these amateur lunar spacecraft.

Now we've established that for a 70-cm downlink a command station dish on the order of 18 meters in diameter will produce an acceptable beamwidth. However, will it exhibit adequate gain? Fortunately, that's an easy calculation, as the maximum voltage gain of any dish approaches its circumference, measured in wavelengths. 18 meters times pi, divided by 70 cm, gives us a voltage gain of about 80. Power gain is voltage gain squared, or about 6400.

That figure, however, is best case for a perfectly illuminated dish. Let's assume that our antenna's illumination efficiency is only 50%. We can thus expect half as much power gain, or a power ratio of 3200, which equates to +35 dBi.

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The SETI League, Inc. Link Analysis
User specifies variables shown in bold

Transmitter:	Receiver:
Frequency = **435** MHz	Eff. antenna diarn. = **18** meters = 59.055 ft
λ = 69.0 cm	Illumin. Efficiency = **50%**
Transmit Power = **1.0E+00**	Computed Antenna Gain = 3.4E+03
W = 0.0	Ap = 35.3 dBi
dBW = 30.0 dBm	Antenna Half Power Bearnwidth = 3.9E–02
Eff. antenna diam. = **0.4** meters = 1 ft	Radian = 2.3E+00 degrees
Illumin. Efficiency = **50%**	Drift Scan Time (zero declination) = 9.0E+00
Computed Antenna Gain = 1.7E+00	min = 542.1 sec
Ap = 2.2 dBi	Recovered Power =
Antenna Half Power Bearnwidth = 1.8E+00	P inc + G ant = –129.8 dBm
radian = 1.0E+02 degrees	System Noise Temperature = **100**
Effective Isotropic Radiated Pwr = 1.7E+00	K = –4.6 dB/To
W = 32.2 dBm	Detector Noise Bandwidth = **2.00E+04**
	Hz = 43.0 dB/Hz
Path:	Receiver Noise Threshold = kTB = 2.76E–17
Range = **1.30E–08**	J/S = -135.6 dBm
parsecs = 4.238E-08	Integration Time = **5.00E–05**
LY = 4.0E+08 m	sec = 0.0 dB/cy
Free Space Isotropic Path Loss = 197.3 dB	
Incident Isotropic Power = EIRP - path loss = –165.1 dBm	Signal to Noise Ratio = 5.8 dB

Table 1. Lunar link analysis (example).

Given our previously calculated incident isotropic power of –165 dBm, adding in the above antenna gain suggests that something like –130 dBm of signal will reach our receiver. Is this enough signal to close the downlink? In order to determine that, we need first to compute receiver noise and then derive signal-to-noise ratio (SNR).

The receiver's noise threshold, found from Boltzmann's Law, is kTB, where k is Boltzmann's constant, T is the system noise temperature (let's assume 100K, a fairly typical figure for good antennas coupled to decent preamps, with minimal feedline loss), and B is the bandwidth of the receiver, which must, of course, be compatible with the transmission bandwidth.

I'm going to arbitrarily assume a 20-kHz receiver bandwidth here, adequate for a 9600-baud BPSK digital link (and fairly common for receivers used on our typical digital ham satellite links). Plugging into Boltzmann's Law, we come up with a receiver noise threshold of –136 dBm. Good! Our noise is about 6 dB weaker than our signal, so we can boast a positive 6-dB SNR. Given reasonable error-correction algorithms, this is sufficient to achieve a solid digital downlink.

Of course, if we desire a higher data rate, or choose to use a different downlink frequency, we have to repeat the whole analysis, but you get the idea. The bottom line is that with daunting but not discouraging dishes we can close the downlink loop from the Moon, with nothing more than a 1-watt transmitter into a dipole. It's not that I'm proposing so simple a transmitter for ASMO or ESMO, but if a single watt at UHF will do the job, then anything else will likely just make things better.

All the above are back-of-the-envelope estimates. For more precise calculations, we use a link analysis spreadsheet. The one I use (see Table 1) is actually designed for radio astronomy, so it has an interesting quirk: Distances are input in parsecs! Fortunately, the spreadsheet converts this bastard unit first to light years and then to meters, so I had to work backwards from the lunar distance in meters to determine what distance to plug in. There are a few other factors computed by the spreadsheet that we have not discussed, but the bottom line shows an SNR very close indeed to what we estimated.

We have reviewed the tools and techniques necessary to analyze the lunar link. Should the students developing the ASMO and ESMO spacecraft so request, I'm sure AMSAT now stands ready to help them on their way to the Moon—and back.

73, Paul, N6TX

Note

1. The anticipated mass and size of the ASMO and ESMO payloads is actually expected to significantly exceed the highly constrained CubeSat standards. However, if we can demonstrate a reliable Moon-Earth link with CubeSat-type power levels, we can certainly do much better with larger and more powerful spacecraft.

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

The Old World of AMSAT

In the Winter 2008 column we reviewed the new world of AMSAT. This time I would like to review how we got to this point in time, 50 years after the launch of Sputnik I. Perhaps this will provide some insight into the attitudes we exhibit today.

In the Beginning

In the beginning, there were no amateur radio satellites. As a matter of fact, there were no satellites. In the 1950s the United States and Russia were engaged in a weapons race to see who could produce the first intercontinental ballistic missiles. One way of showing off the capability was to place a payload in Earth orbit. The Russians won this initial chapter with the launch of Sputnik I on October 4, 1957. While not an amateur radio satellite, the RF beacon on this satellite was placed on frequencies such that the signals could easily be received with minimal equipment. Guess who had a lot of this equipment and the scientific curiosity to listen for it, record it, and see what they could do with it? Amateur radio operators.

The HF beacon was on 20.005 MHz, which was just outside of the 15-meter amateur radio band and close enough to 20.000-MHz WWV transmissions to make it easy to locate. Many hams did hear this initial "bird." I listened but did not understand the situation well enough to actually locate and track the bird. Had I been more patient and applied the principles of physics that I learned in high school and my first year of college, I might have heard it with my Hammarlund HQ-129-X receiver (which I still have) and figured out what was up.

Ultimately, after many failures on both sides, the United States did launch satellites into Earth orbit, and it was only about four years later, on December 12, 1961, when we did launch the first amateur radio satellite, OSCAR-1. This Orbiting Satellite Carrying Amateur Radio was designed and built by a group of hams in Sunnyvale, California, located in the San Francisco Bay area. This group came to be known as Project OSCAR and still exists today. Many of them worked in the aerospace industry and had connections with the new space programs. It was these connections that permitted them to identify a potential "ride" to orbit as ballast to help prove the lift capability of a new launcher. This was done in true amateur radio spirit at minimal (or no) cost. Thus, this pattern was established and utilized for many more launches over the years.

Onward and Upward

It is beyond the scope of this article to discuss each satellite that was developed and launched over the next 50 years. A very good job of that is done by Martin Davidoff, K2UBC, in chapters one and two of his book *The Radio Amateur's Satellite Handbook*, published by the ARRL. A summary of all launches up to the late 1990s is also available in Appendix A of the book. Additional data, primarily on launches since the publication of Martin's book, are available on the AMSAT website (http://www.amsat.org).

Initially, amateur satellites were all in Low Earth Orbit (LEO) and were nothing more than beacons with crude forms of telemetry. For example, the code speed on the "Hi" that was transmitted by OSCAR-1 varied as a function of temperature. Also, early efforts were short lived, since they "died" when the batteries ran down. There was no recharging capability built into these early satellites, but their purpose was served by providing an introduction to the Amateur Radio Space Program.

As the "techies" (or satellite builders) became more proficient and more numerous, more capabilities were added with each successive launch. First came transponders and recharge capability, and then more modes and frequencies. Initially, everyone was happy to get whatever capability was offered by each launch. As time went on and new modes and frequencies were added by the techies, the user community began to see this as a drain on their meager finances to add the new receivers, transmitters, antennas, etc., to support each new capability. They also developed a tendency to resist change and wanted more satellites, but not new capabilities. Of course this was no fun for the techies, so they went on developing the new modes and frequencies. The early standard mode was known as Mode A (2 meters up and 10 meters down). Many of these were built, and even the newest birds retained Mode A in addition to whatever new capabilities they provided.

Early efforts were led by the western world, and in 1969 leadership moved from Project OSCAR to a new organization, The Radio Amateur Satellite Corporation, or AMSAT. Other countries soon joined the worldwide AMSAT umbrella, and we had AMSAT-NA (North America), AMSAT-DL (Germany), AMSAT-UK (United Kingdom), and several others. Cooperation among these groups soon produced some great birds. One of the most notable of these is AMSAT OSCAR-7, or AO-7. This bird included Mode A and a new Mode B, or 70 cm uplink and 2 meter downlink. AO-7 was launched in 1974, died in 1981, and returned from the grave in 2002. It is still with us today as long as it is in sunlight.

In the late 1970s the Russians entered the race and produced some great Mode A birds. This series started with Radio Sputnik-1 (RS-1) and went through RS-22. The series also included Iskra 2 and Iskra 3. These birds were mostly conventional Mode A linear transponders and beacons. However, a popular CW robot was introduced in this series, and later on, the all-HF Mode K was introduced. I made many contacts working a 15m/10m split with my HF mobile and a dual-band mobile antenna. Very interesting studies of HF propagation were possible with Mode K.

These were all Phase I (beacon only) and Phase II (transponder included) LEO satellites.

Phase 3, HEO Satellites

In the late 1970s, thoughts soared to the High Earth Orbit (HEO) concept. The planned orbit was a highly elliptical one that was pioneered by the Russians and called a Molynia Orbit. This orbit had a high apogee (about 36,000 km) and made about two orbits per day. It produced approximately eight hours of operation per

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day for most amateur radio operators instead of the short 10- to 15-minute passes of the LEO satellites. The first of this series, Phase-III-A, ended with a launch failure in 1980. Phase-III-A achieved the first geo-stationary orbit, on the floor of the Atlantic Ocean. Not very useful!

A quick turnaround effort was performed, and in 1983 the first HEO amateur satellite, AO-10, was launched. This truly revolutionized amateur satellite operations and overnight became immensely popular. Hams could now ragchew worldwide for hours on end and even work DXCC through a satellite instead of relying only on the HF bands. AO-10 led a long life, and although somewhat handicapped, performed until the late 1990s. AO-10 was a Mode B satellite, but it also introduced Mode L (L band up and 70 cm down) into the mix.

In 1988 Phase-III-C became AO-13 and added another HEO satellite to the mix. It retained the Mode B and Mode L capabilities of AO-10 and added a new Mode S (70 cm up and S band down). Other variations were included as well. This bird performed well and actually achieved its planned orbital parameters. However, an unforeseen problem was discovered with the orbit that led to AO-13 de-orbiting in the fall of 1996. AO-13 operated well until the "bitter end," but it left a huge void in amateur satellite operations. AO-10 occasionally was still usable at this time, but could not be relied upon, since we no longer had control over it.

Meanwhile, in 1990 a new plan developed for Phase-III-D. This was to be the largest, most powerful, greatest Mode diversity, most expensive amateur satellite ever built. A project of this size required the cooperation of all the AMSATs of the world. Without spending a lot of time and space, this satellite was developed over the next ten years and eventually became AO-40 upon launch in 2000. It went through a complex, textbook perfect launch, but soon afterwards developed problems during commissioning. Many of its capabilities were rendered useless.

However, it finally achieved a fairly stable Mode S capability which was gaining rapidly in popularity among the amateur satellite users once they realized it didn't cost much for a small dish and a surplus 2400- to 144-MHz down converter. Things were really beginning to "look up" when something happened to the satellite's power system and it went silent. All efforts to diagnose the problem and re-gain control thus far have failed. With AO-40's demise, the world was now without a Phase-III satellite capability for the first time since 1983 and it hurt. Many active satellite users simply coiled up into their shells and refused to do anything else until another HEO satellite became operable.

Microsats

In the late 1980s, AMSAT-NA pioneered the concept of a small satellite with a common satellite bus structure and a configurable experiment package. The first group of these satellites was launched into LEO in 1990, and they continue in operation today. Many of these are/were store-and-forward digital birds. However, some had voice and/or imaging capabilities. One of the early ones, AO-16, recently has been given a new life as a voice bird with FM up and DSB down. Others may follow. Other satellites in this series pioneered the single-channel FM satellite capability that has become very popular among new and experienced operators alike. However, many of the older HEO operators hate the concept and will have nothing to do with it.

CubeSats

Last, but not least, I will mention the CubeSat concept. CubeSats are another very small, standardized satellite space frame. Several of these can be launched from a CubeSat launcher riding on a conventional launch vehicle. This class of satellites is popular among colleges and universities as class projects to learn, hands on, about aerospace engineering. Many of these have been built and launched throughout the world. They are typically short lived LEO birds with a specific experiment or experiments on board of primary interest to the students who built them. They typically enlist help from the amateur satellite community for construction advice and data recovery. Many of these exist today and many more are on the drawing boards.

Summary

This column is intended to impress upon readers the proud, prolific, and worldwide history of amateur satellites. As you can see, one of the best chapters is the HEO chapter. We sorely miss these birds, and AMSAT has a vision to return to HEO capabilities with Phase-III-E, Eagle, and the potential Phase-IV-Lite, described in the last column.

Please don't give up hope. Subscribe to the "can do" concept described in the last column and "put your money where your mouth is." Extend this to your talents and become a part of a worldwide team devoted to the Amateur Satellite Service.

By far the largest hurdle we are facing is the raising of funds to support this service. The biggest cost is that of the launch. In the old days, we were able to obtain free launches. We are now in the era of "no free launch." The Phase-IV-Lite effort offers a way of producing satellites that will be fun, challenging, and affordable through the interesting "big spenders" in the public service and the education capabilities that it will provide. These "big spenders" are necessary for our continued existence as a service.

See you next time! 73, Keith, W5IU

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Pitfalls in Stacking Antennas

Last time, in the Winter 2008 issue of *CQ VHF*, I challenged you to tell me what is wrong with the antenna in photo G (in the current column, photo A). I have to admit it's not easy, and the previous owner of this antenna never figured out why it was such a terrible 432-MHz SSB mobile antenna either. It took me a while to see the problem. However, congratulations to W6OAL, N5SRE, and W6TCP, all of whom saw the assembly error. Take a close look at how someone flipped over the bottom element so that the coax connectors would go together more easily. To make the connectors a little easier to attach, the bottom element was flipped. Therefore, one PL259 is pointing up and the other is pointing down. The phase of the two elements was inadvertently reversed.

In figure 1 we have the pattern showing what a normal set of phased omnidirectional antennas would look like in free space. Now look at figure 2, in which the phasing is flipped 180 degrees on one of the antennas. There is now a deep null right at the horizon—a bad pattern for a mobile antenna. In figure 3 we have an EZNEC simulation of what the pattern of these out-of-phase antennas would look like when mounted on a car or truck. See how there is very little signal near the horizon? The antenna might work for an OSCAR overhead pass, but it's a lousy pattern for UHF grid hopping.

Mobile antennas are not the only place where you can see this. How about putting up two Yagis on 2 meters to hit that far-away repeater? If you reverse one of the Yagis so that the coax connectors are pointing towards one another, you may have just switched the phasing on one of the antennas and have an out-of-phase stacking arrangement. On SSB you just have a horrible antenna. On FM, where the Yagis are usually stacked side by side, you notice that when pointed right at the repeater, the signal is pretty near S0. Turn a few degrees off to either side, and the signal comes up. You have *not* successfully stacked that pair of Yagis . . . and for those of you who are about to e-mail me, yes, it is possible to stack unusual configurations even with the elements flipped using unequal lengths of coax in the power dividers. I will touch on that discussion later in this column.

The winner in the improperly assembled antenna category goes to a Cushcraft Jr. Boomer for 144 MHz I picked up at a garage sale, of all places. The XYL running the sale said that the owner had not been happy with the antenna. I later noticed that some of the directors were longer than some of the reflectors. That's not the usual arrangement for Yagi elements. Out came the assembly instructions for the Jr. Boomer I already had in the air. I did a quick check, and out of the 14 elements, including the driven element which only fits in one hole, only three elements were in the right holes. Yes, it does make a difference which elements go where. It looked as if that antenna had been randomly assembled. I then reshuffled the elements and stacked it with my existing Jr. Boomer. I made sev-

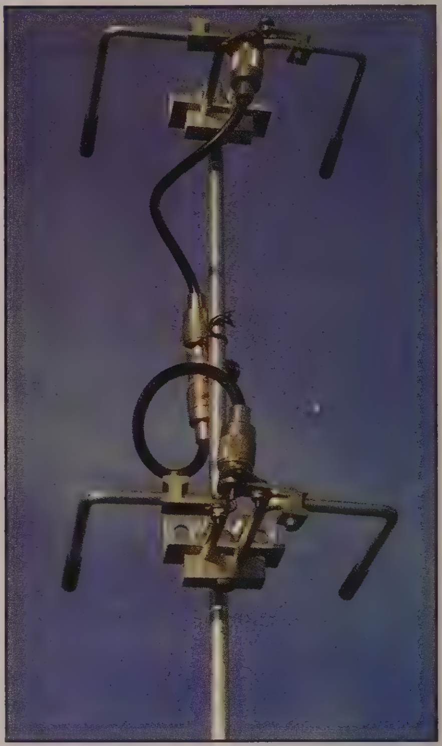

Photo A. What's wrong with this antenna?

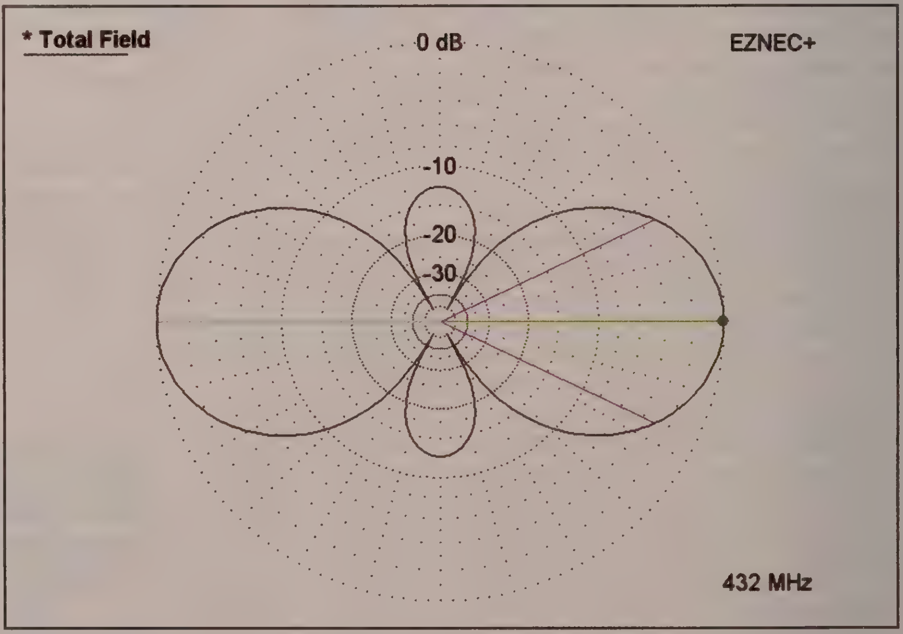

Figure 1. Pattern for the 432-MHz mobile antenna as it should be.

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eral EME contacts, a few meteor-scatter QSOs, and a contact with W5LFL on the space shuttle with that pair of Jr. Boomers. All the QSOs were CW and SSB (no JT65 back then). Well, W5LFL was on FM, but that one was line-of-sight. But I digress.

Yes, it is possible to add an extra 1/2 wavelength of coax to one side of the phasing lines and flip the flip, getting both antennas back to the same phase, but this usually is not recommended.

Photo B is an example of this flip of a flip. It is a sector patch antenna I made for a client. Note that one patch is fed from the bottom and one from the top, so the patches are naturally 180 degrees out of phase. You can also see how the coax connector is not exactly half way between the two patches. To one patch I have a 1/4-wave matching line, and to the other patch I have a 3/4-wave matching line. Now the antennas are matched and back in phase.

Photo C is a more typical example of how a pair of patch antennas would be phased. However, the flip of the flip gave the final size, gains, pattern, and polarization the client wanted.

Another Stacking/ Phasing Technique

Here is another stacking/phasing technique that came out of the CATV industry almost 50 years ago. Back then the

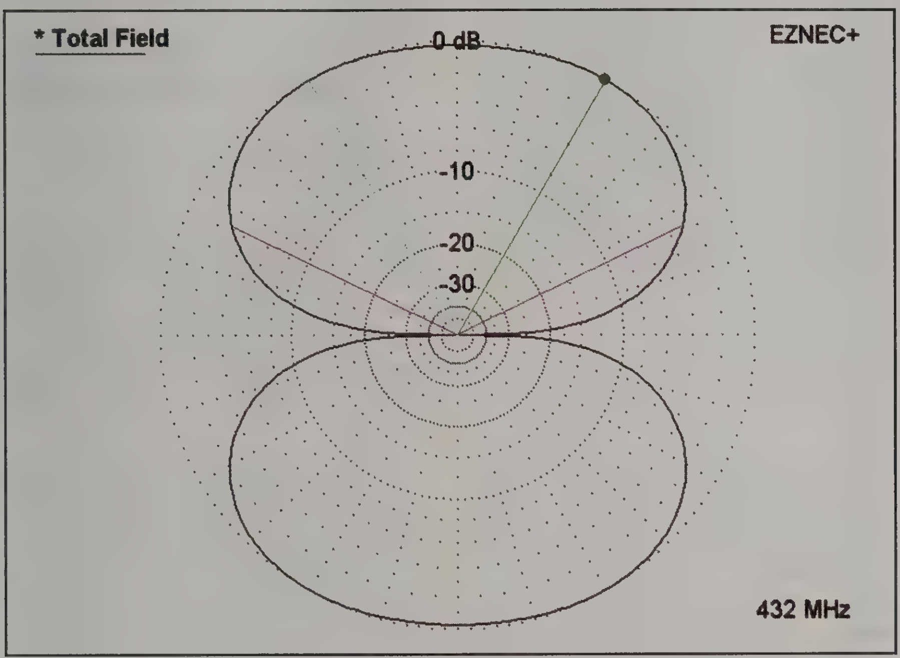

Figure 2. Pattern when one of the 432-MHz mobile antennas is flipped.

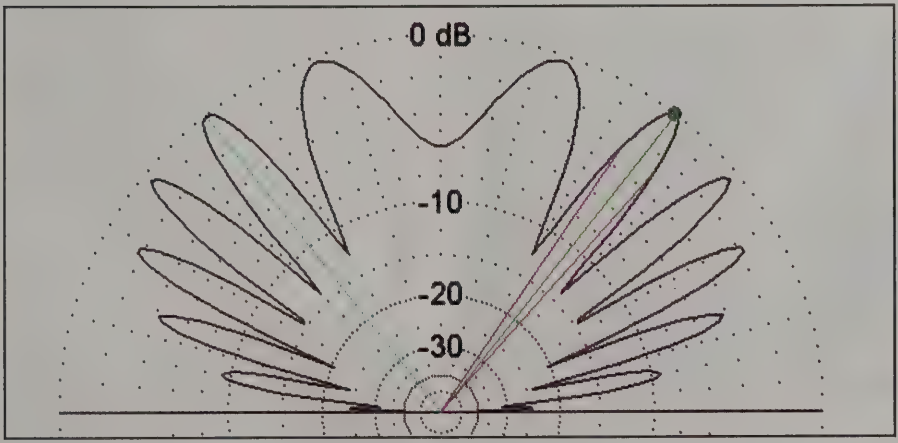

Figure 3. Pattern of the stacked omnis when mounted on a vehicle.

Photo B. Stacked patch antennas with power divider and identical phasing.

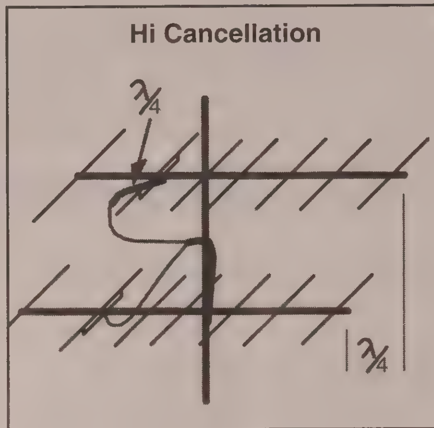

Figure 4. One-quarter-wave offset stacking to increase Yagi front-to-back ratio.

cable companies put up a tall tower and pulled in TV signals from 100 or so miles away. This TV signal was amplified and distributed to customers. Communication satellites were still many years in the future. At this height it was common to pick up a second TV station on the same channels. The on-channel interference gave the paying customers zigzags and bars on their screens, so it was very important for the CATV antennas to reject signals off the back.

The antennas were stacked with one antenna $^1/4$ wave in front of the other one (figure 4). Next the coax in the power divider was made $^1/4$ wave longer on the forward Yagi. This was $^1/4$ wave longer in coax. Thus, the coax velocity factor was used in the calculations. From the front, the radio wave has to travel $^1/4$ wave longer just to get to the back antenna. However, then the radio wave travels $^1/4$ wave less in the coax, so all the signals combine in phase.

Now let's have a radio wave come in from the back of the antennas. The radio wave has to travel $^1/4$ wave farther to get to the antenna with $^1/4$ wave more coax. The signals are now $^1/2$ wavelength out of phase and neatly canceled. With care, it is possible to get an additional 20 dB of front-to-back ratio out of the antennas' natural front-to-back ratio. This is a good technique when you really need a very high front-to-back ratio.

As always, I welcome your antenna questions and ideas for future antenna topics. You can drop me note at my e-mail or snail mail address on the first page of this column, or visit <www.wa5vjb.com> for more antenna topics. The weather is nice, go get some antennas in the air!

73, Kent, WA5VJB

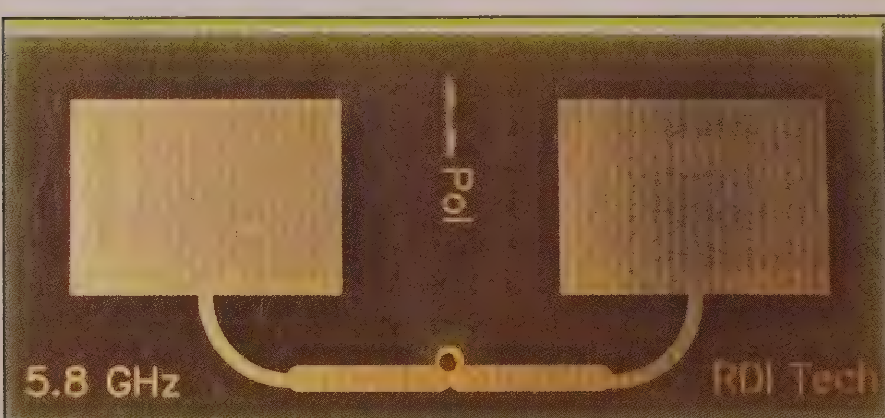

Photo C. Stacked patch antennas 180 degrees out of phase with an extra $^1/2$ wave in the power divider.

HSMM *(from page 81)*

but more recently they have been known as laptop PC cards. Note that unlike other PC wireless cards, theses devices do *not* have a built-in antenna. They are designed for an operator-supplied external antenna, such as an MFJ 1800, etc.

2. Another type of transceiver/adapter comes with a USB interface. This is often considered a superior interface for most HSMM stations. The reason for this has nothing to do with the quality of the transceiver, but rather the fragile nature of the tiny external antenna connectors (MMCX, etc.) that are found on the PC cards. They are not really designed for frequent plugging and unplugging. Without extreme care, they can easily be torn out. An example of a wireless USB adapter is shown in photo 2.

The transceivers with a USB interface to your laptop or computer will usually have a normal TNC connector.

3. Linksys and other manufactures also produce similar cards for the expansion slot on the rear of a desktop PC, too. An example is the Linksys WMP54G Wireless-G PCI Adapter, which is shown in photo 3.

A final note: make certain that the transceiver you purchase has an antenna that is removable, and thereby has an external antenna connector of some type!

Until next time . . .

73, John, K8OCL

By John Champa,* K8OCL

Getting on the Internet
Your First HSMM Radio Station

In our previous column we discussed an HSMM radio repeater (Wireless Access Point/Router + PC) and the setup of a simple RAN (Radio Area Network). This time we will look at what is in a basic HSMM radio station (client). However, first let us look at another related area.

HSMM Radio Mobile I-Gate (Internet Gateway)

By combining an HSMM radio repeater with a laptop having broadband wireless Internet access such as provided by Sprint and other carriers, it is possible to provide shared Internet access for the radio stations connected to the RAN. Field experience with such a configuration indicates several special steps need to be taken for this configuration to work effectively:

1. Use a broadband card, or ED-VO card with an external antenna port.
2. Mount the broadband Internet access external antenna on the roof of your vehicle as far away from your HSMM radio antenna(s) as possible to avoid desensing.
3. Use *two* external antennas, if possible, on your HSMM repeater in order to achieve receive space diversity.
4. Mount the two HSMM antennas a minimum of 9–10 inches (approximately two wavelengths) apart; the more the better, up to about 10 wavelengths.
5. Inverter selection—determine the power requirements of the laptop and the HSMM repeater and any other devices, such as LED lights, etc.
6. Then double that wattage figure to determine the size of the inverter needed for the system. You want the inverter to run cool and easy.

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e-mail: <k8ocl@arrl.net>

Photo 1. An HSMM Area Survey Antenna. (All photos courtesy of Fleeman, Anderson, and Bird; <http://www.fab-corp.com/>)

This should allow you to drive your mobile I-gate vehicle into a gathering of other radio amateur EMCOM vehicles and provide them with immediate network connectivity (RAN) and Internet access. Let us know how your experiments go in this area, and we will pass them along to our readers.

Photo 1 shows an HSMM Area Survey Antenna. A pair of these antennas should work well for your mobile I-gate station's repeater antenna system.

Basic HSMM Radio Station

The heart of a typical HSMM radio station is a computer-operated wireless local area network (WLAN) 2.4 GHz radio transceiver commonly called a "Wife card" named after the consortium (Wireless Fidelity) that certifies such devices for meeting the IEEE standards for 802.11 modulations.

It is simply a PC wireless client adapter card. It usually slides into a slot in the side of a laptop, but more on that later. It will probably cost well under $80, and perhaps as little as $5. Many ham markets

Photo 2. A wireless USB adapter.

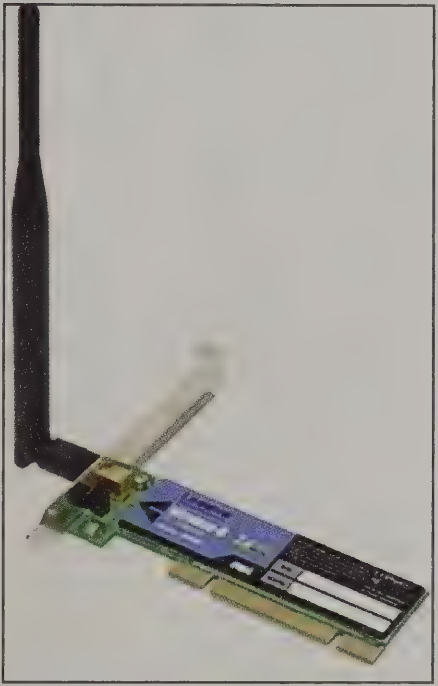

Photo 3. The Linksys WMP54G Wire less-G PCI adapter.

sell the older 802.11b type cards (which are just fine for HSMM radio work) for just a few dollars. Most of these small approximately 100-mw radio transceiver cards come in three forms:

1. The most common form is a PC card. Earlier these were called PCMCIA cards,

(Continued on page 80)

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Remembering Sir Arthur C. Clarke

The author visiting Sir Arthur in his Colombo home, January 2000.

The official obituaries have already been written most eloquently. This is a personal remembrance of Arthur Charles Clarke—science-fiction author extraordinaire, advisor to The SETI League, life member of AMSAT, and the world's second greatest communications engineer—who passed away on March 18, 2008 at the age of 90 of complications arising from post-polio syndrome.

Although Clarke had a direct influence on my entire career, and we corresponded from time to time, I did not actually meet him until January 2000. It was a memorable meeting (more about that later). The first Clarke science-fiction novels I read (in high school) included *Childhood's End* and *Prelude to Space*. However, it was his brief article "Extra-terrestrial Relays" in the monthly radio journal *Wireless World* that had the most profound early impact on me.

In 1961 I was a high school student and a radio ham, and the youngster sitting in the back of the room at Project OSCAR meetings watching my mentors design and build the world's first non-government communications satellite. I remember thinking, "This is what I want to be when I grow up." We had read Clarke's seminal article, and (although OSCAR 1 was a low-orbiter) we were already thinking about the geosynchronous orbit that he "invented" back in 1945.

Fast forward to the early 1970s. I had become an aerospace engineer and was running a small Silicon Valley microwave company, developing receivers for the first geosynchronous Earth imaging and communications satellites. I had a small (16-foot, gigantic by today's standards) satellite TV dish in my back yard, and read in *Coop's Satellite Digest* that Clarke himself had a similar dish perched on the balcony of his Colombo residence.

That Clarke lived in Sri Lanka bore a certain technological irony. Because the Earth's center of mass is not at its geographical center (ours is a lumpy planet), even perfectly circular satellite orbits tend to decay over time. From the Clarke Belt, if active station-keeping is disabled (or if the satellites run out of the hydrazine fuel burned by their thrusters), the birds tend to drift to the "low" point in their orbit, a stable resting point over the Indian Ocean. This satellite graveyard was well in view of Arthur's 5-meter dish, so I like to think that the dormant geosats were all going home to papa.

In 1979 (by now an engineering professor), I happened to be in Hawaii touring the Comsat telemetry, tracking, and control (TT&C) station on the north end of Oahu. My host showed me a brief PR film called "Pathways to the World," narrated by none other than Arthur Clarke. There was a scene showing him standing under his dish, and I thought this would be a great thing to show my students. I asked the Comsat people how I might obtain a print of the film. "Do you have access to an Intelsat terminal?" I was asked. I did indeed (my old homebrew 16-foot dish and C-band receiver). I was given a satellite name, and a transponder number, and a time about a week hence. When I arrived home on the mainland, I aimed my dish and tuned my receiver appropriately and videotaped "Pathways to the World." How's that for appropriate use of Clarke's technology?

I've since shown that tape to a couple of thousand students and still cherish it in my video collection. Following the US Congress canceling the NASA SETI program in 1993, several organizations (including the nonprofit, membership-supported SETI League) emerged to fill the void. I was tapped as The SETI League's Executive Director, and one of my first tasks was to recruit luminaries to serve on our advisory board. Arthur accepted graciously, without hesitation. I enjoyed our rich e-mail correspondence over the past several years, touching sometimes on SETI matters, sometimes on communications technology and science, and sometimes on science fiction. When I went on a lecture tour to India in 2000, Sir Arthur kindly invited me to take a side-trip to Colombo and pay him a visit.

Arriving at the Galle Face Hotel in Colombo, I saw a familiar face in the lobby—Arthur's brother Fred, whom I

*Executive Director Emeritus, The SETI League, Inc., <www.setileague.org>
e-mail: <n6tx@setileague.org>*

had met in the UK a few years prior. Not only did I not know we were staying in the same hotel, I had no idea Fred was in Sri Lanka! That's how small a world we inhabit, and Arthur helped to make it so. Fred's wife Babs had died just two months earlier, and Arthur came to visit his brother and to mourn. Fred and I stayed up most of the night, sharing songs and poetry and reminiscing about this elegant woman who had dazzled me the one time I met her.

The next day it was off to Arthur's home (Fred and I together). When questioned by the hotel concierge earlier as to my business in Colombo (there was a war on, so they asked such questions), I simply said I was there to visit a friend. Then, as I hired a car and gave that same concierge the address, his eyes widened in a mixture of recognition, surprise, and respect. It seems Arthur's house is well known in Colombo!

You may recall that when Isaac Asimov died a few years back, Clarke eulogized him as "the world's second-greatest science fiction writer." That gave me an idea.

Visiting Arthur at his home, I brought a gift, as is customary. It was not the traditional bottle of wine, since I no longer lived in California. Instead, I wrote the song "Extraterrestrial Relays," brought along my guitar, and had a chance to sing it to Arthur, his staff, and his brother. Arthur was delighted and asked for a copy. I was prepared and made him a formal presentation of the original. The sheet music is inscribed "to Sir Arthur C. Clarke, the world's second greatest communications engineer." I heard later that Arthur had framed that page and placed it on the wall in the room of his house that he wryly called his "ego chamber."

Arthur once told me that he would gladly lend his name and support to our SETI League efforts, and that I could feel free to ask him for anything—except money. I respected that request, figuring that his name on the masthead was worth far more than millions in the bank. However, during my one visit to Colombo, he gave me a check anyway, and that's a story in itself:

When Clarke invented the geostationary communications satellite (OK, so some will say that Tsiokolvskii *really* invented it; Clarke merely refined and published it), he coined the contraction ComSat, for Communications Satellite. He contributed the name to the public domain, never expecting such technology to emerge within his lifetime. Years later, when the Communications Satellite Corporation was formed, it adopted the trademark Comsat. However, its leaders knew where the term really came from, and although under no legal obligation to do so, they wanted to make a token payment to Clarke, in gratitude. They gave him one share of Comsat common stock.

Over the years, what with stock splits and dividend reinvestments, that one share had multiplied to several, and Clarke began to receive small checks in the mail from Comsat from time to time. I was in his house when one of those checks arrived and just happened to be talking with Arthur while he was going through the mail. He promptly handed me a dividend check from Comsat, saying, "Here—for The SETI League."

I never cashed that check. It's framed now and hanging on my wall, and some poor Comsat accountant is probably wondering to this day why the company's accounts show a discrepancy of $4.75.

Now, whenever I look at that check I will fondly remember Sir Arthur Charles Clarke, the world's second greatest communications engineer. Next time I see Fred Clarke, it again, sad to say, will be to mourn.

73, Paul, N6TX

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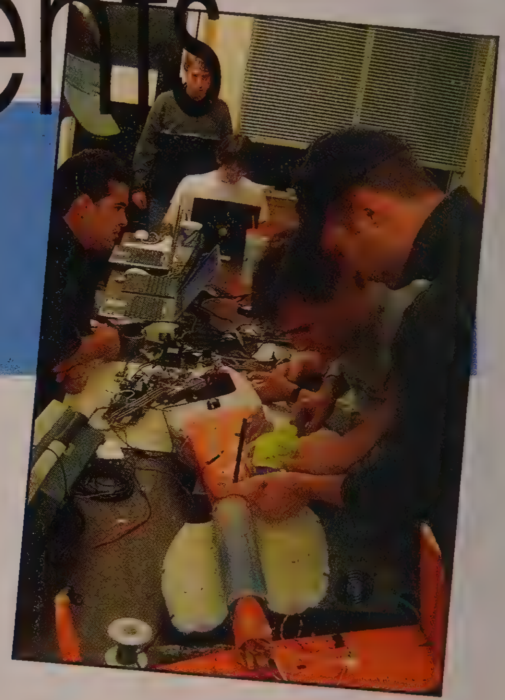

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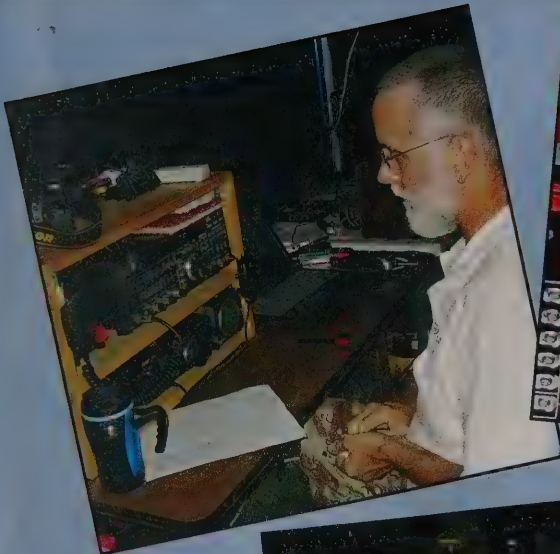

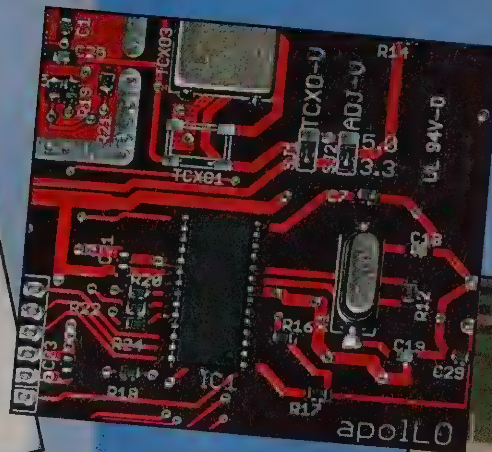

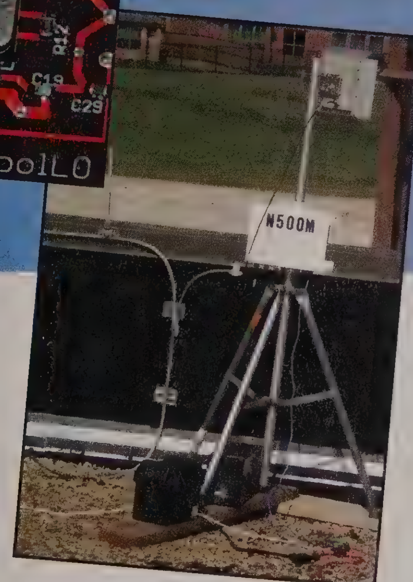

COLUMNS

DEPARTMENTS

On The Cover: The main cover photo shows an AMSAT satellite demonstration in the parking lot of this year's Dayton Hamvention®. For details see the "FM" column on p. 48 (photo by KØNR). Insets, left to right: The Holmdel horn antenna circa 1960; see "The Basement Laboratory Group" by WA2VVA on p. 31. A dual-band loop antenna; see "2500 Miles with Just a Loop?" by WB6NOA on p. 22 (photo by WB6NOA). A three-processor, two VHF radio system ready for a trip into space; see "The BIG BLUE Projects: One Student's Perspective," by KY1GDC on p. 40 (photo courtesy of KY1GDC).

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

TAPR/DCC Conference

This year's annual TAPR/DCC Conference will be held in Chicago, Illinois, September 26–28. According to TAPR (Tucson Amateur Packet Radio, Inc.) vice president Steve Bible, N7HPR, from its beginnings 27 years ago "it has grown to be the premier national digital conference covering digital voice and data technologies." Several years back the TAPR organization combined with the ARRL and its Digital Communications Conference to form the joint conference.

History

Digital communications experimentation has its roots with the Vancouver Amateur Digital Communications Group, which was experimenting with that mode as early as the late 1970s. The group's work caught the attention of Paul Rinaldo, W4RI, who through the League established the first computer networking conference in October 1981 in Gaithersburg, Maryland.

It was in that same month and year of 1981 that a group of hams who were members of the Tucson Chapter of the IEEE came together to discuss the possibility of developing an affordable packet terminal node controller (TNC). Pioneering work between Lyle Johnson, then WA7GXD and now KK7P, and Don Conners, KD2S, led to the development of a kit with the nomenclature TNC1. Their kit led to the second-generation development called TNC2, which became the basis for most packet networks today.

The following year TAPR was formed. Initially promoting packet radio, it now embraces almost any digital ham radio technology development. One of the most popular recent technological developments is software defined radio, or SDR. Growing out of the work of TAPR was Gerald Youngblood, K5SDR's development of the SDR 1000 and now its very well received successor, Flex Radio's SDR 5000.

Cooperation and Talent Mergers

Thanks to Bob McGwier, N4HY, who has common connections with Youngblood, TAPR, and AMSAT, at the 2006 AMSAT Symposium the AMSAT leadership was encouraged to use SDR technology in their forthcoming Eagle Project. This development has resulted in the merger of talent between AMSAT and TAPR. Evidence of this merger was made clear at the 2007 Dayton Hamvention®, where the linking of two SDR 1000 radios was demonstrated at the AMSAT booth and the first joint AMSAT/TAPR banquet was held at the Wright Patterson Air Force Base Museum.

Preceding the AMSAT–TAPR talent merger was another merger of sorts between the ARRL and TAPR. By 1993 the League's computer-networking conference had become the Digital Communications Conference (DCC). Realizing that the two organizations had much in common, the leadership of the organizations signed a memorandum of understanding (MOU) for the purpose of combining their annual meetings. Thus, in 1996 the first joint TAPR/DCC meeting was held in Seattle, Washington. Two years later it was held in Chicago. Now, 20 years later, the joint conference has returned to the "Windy City." For more information on this year's conference see the website:<http://www.tapr.org/dcc>.

My thanks go to TAPR president Dave Toth, VE3GYQ, TAPR vice-president Steve Bible, N7HPR, and TAPR/DCC co-chair Mark Thompson, WB9QZB, for supplying information for this section of my editorial.

Award for Design Achievement Winner

New in this issue of *CQ VHF* is the publication of the winner of Southeast VHF Society's annual Design Achievement Award. Awarded at the society's annual conference and jointly sponsored by the society, Downeast Microwave, and Mini-Circuits™, and this year joined by *CQ VHF* magazine, the winner receives a prize of either $1,000 cash or $2,500 in Mini-Circuits™ products, a gift certificate from Downeast Microwave, and this year we include a year's subscription to *CQ VHF* along with the publication of the project's paper in the magazine.

This year's winner is Steve Hicks, N5AC, who designed a USB programmable, highly stable local oscillator for microwave transverters. Steve illustrates the problem of instability in microwave transverters by way of his opening vignette of a fictitious QSO in which the operator with whom he is having a QSO is complaining that Steve's transmit frequency is not on the same frequency as it was the previous time the two of them made contact with one another. You can read his solution beginning on page 6.

The partnership between Mini-Circuits™ and the Southeast VHF Society has been ongoing for a number of years, resulting on several projects being designed using—and thus promoting the use of—Mini-Circuits™ components. It has become a win-win situation for all concerned. With *CQ VHF* magazine joining the sponsorship this year, it is hoped that national attention will be drawn to this very successful competition.

Along with the national attention, it is hoped that other organizations will become encouraged to also sponsor similar competitions. As the editor of this magazine, I can state that should any other organization wish to develop a similar competition, we will extend the offer of the same prize of publishing the project's paper and a free one-year subscription to *CQ VHF*.

Education Partnerships

Speaking of organizations, here is a suggestion for yours or for the company you work for: Become an education partner with a nearby public school. This summer is the right time to find a school and begin the partnership relationship with it.

If you do not know how to go about developing such a partnership, check with the board of education for your target school. Chances are that the board may have in place the wherewithal for your organization to become such a partner. If the board does not, then perhaps your area chamber of commerce may have a program in place for doing so. For an example of how the education partnership program is working for the Tulsa Public Schools and Tulsa Metro Chamber of Commerce, please see the website: <http://www.tulsaschools.org/sp/pie.shtm>.

The bilateral benefits for such a partnership are too numerous to articulate in this editorial. One, however, is the opportunity to become involved as a mentor very early in a child's process of choosing a life career. The child benefits by being given a possible direction for his or her future. The mentor has the satisfaction of knowing that he or she has made a significant, and potentially life-altering, difference in a child's life.

Should you become involved in an education partnership and have a story to tell that is related to our niche of the hobby, please let me know. I would like the opportunity to publish your story in a future issue of *CQ VHF* or via the "VHF Plus" column in *CQ* magazine.

Until next time . . 73, de Joe, N6CL

A USB Programmable, High-Stability Local Oscillator for Microwave Transverters

A problem facing microwave operators, especially rovers, is frequency drift. Here N5AC provides a solution that can be programmed from your computer.

By Steve Hicks,* N5AC

The project described in this article received the 2008 Southeast VHF Society/Mini-Circuits™ Annual Award for Design Achievement. A similar version was previously published in the Society's 2008 conference Proceedings.

I picked up the mic and called again on 3456.1 MHz: "CQ CQ CQ Contest, N5AC, November Five Alpha Charlie, over."

"There you are," the voice came back, "but now you are about 3 kHz low."

"Weren't we about 3 kilohertz high this morning?" I asked.

The Problem

The above on-the-air scenario is familiar to many microwave operators, especially rovers. The amount of frequency drift on the microwave bands varies with band of operation, equipment, and temperature. The cause of the drift is almost always the local oscillator in the transverter, which is primarily responsible for setting the operating frequency of the transverter. A typical 2304-MHz transverter block diagram, shown in figure 1, will explain why.

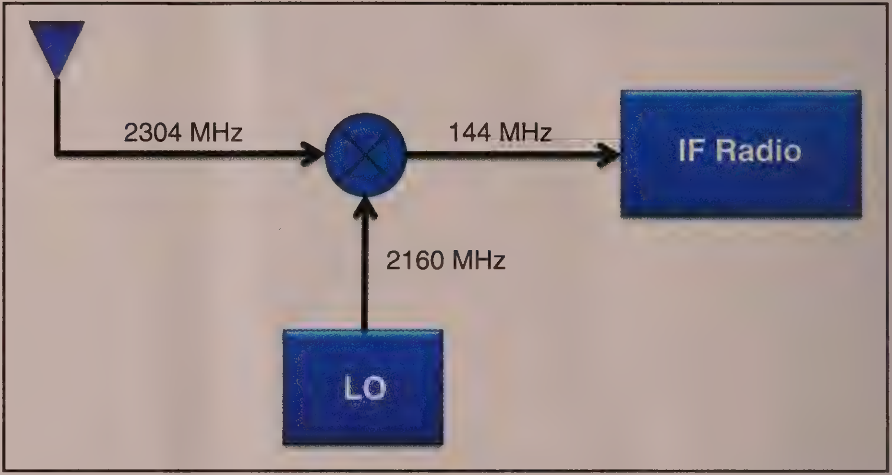

Figure 1. The 2304-MHz transverter (receiver) block diagram. (All artwork and photos by the author)

With a local oscillator (LO) frequency of 2160 MHz, the incoming RF at 2304 MHz will be downconverted to 144 MHz, assuming low-side injection (2304 – 2160 = 144). 2304.1 MHz will be heard on 144.1 MHz, and 2304.2 MHz will be heard on 144.2 MHz. If the LO drifts to 2160.005 MHz, though, 2304 MHz would be heard on the IF radio at 144.095 MHz, 5 kHz low. The IF radio's frequency stability is also important and can affect where signals appear, but with a lower frequency of operation (144 MHz for the IF radio in this case), the stability of the underlying oscillator has 15 times less impact than the microwave LO. Let's try to understand why this is so.

Oscillator stability is often rated in parts-per-million (ppm) across a temperature range. This figure is derived from the design and underlying physics of how the crystal is cut and mounted. A typical rating might be 1 ppm (10^{-6}) from 0–70° C. Parts-per-million indicates how many Hz a signal would move for every MHz of operating frequency. If this oscillator was the basis for a 144-MHz transceiver, the oscillator could move up to 144 Hz (ignoring for the moment mixing going on in the transceiver). That's not far. This same oscillator used on 10 GHz could drift up to 10 kHz over the operating temperature range ($10^{-6} \times 10^{10} = 10^4$)! This is much more significant. Combine with this the fact that many home-brew amateur projects do not achieve 1 ppm and it's evident where the drift comes from.

Therefore, by the time a 100-MHz crystal oscillator is multiplied up by a factor of close to a hundred, a small drift in the base oscillator becomes a massive movement in the microwave bands. Frequency stability on the microwave bands has been more of a luxury for amateurs. Few had it and the rest of us were always chasing everyone around the bands and trying to get on frequency. This problem is not unique to hams, though. Commercial enterprises, such as cellular phone carriers, have all of the same problems. They have to be able to hold a signal steady in the 1900-MHz band and demodulate a digital signal in a handheld transceiver, your cell phone. The solutions to these problems have opened up

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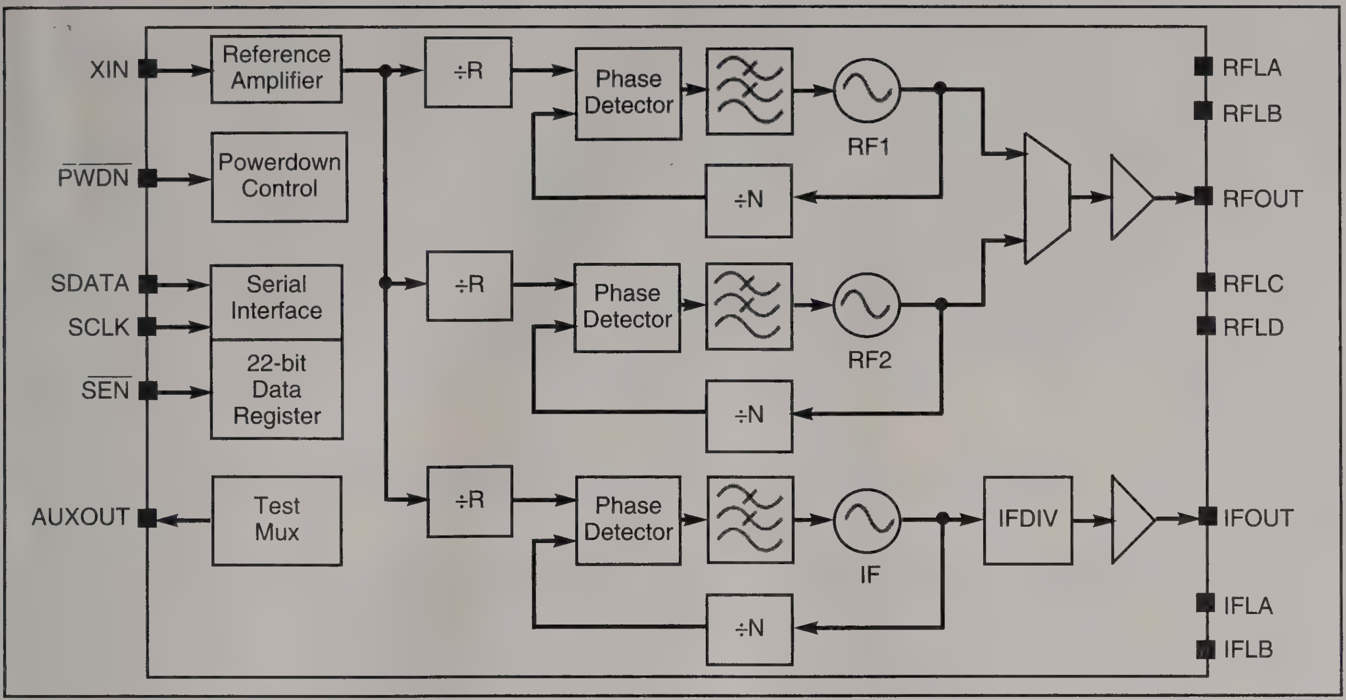

Figure 2. Si4133 synthesizer block diagram.

some new windows for hams to better control frequency stability.

Finding a Solution

By now you may have figured out that I am talking about synthesizers, VCO and PLL integrated circuits, and high-stability underlying oscillators. Many solutions in each of these product categories have emerged as the demand for quality cellular and other handheld communications has increased. More and more of this functionality is also being placed on a single chip to reduce size. It used to be that you would purchase a VCO and a PLL chip and be responsible for your own loop filter, but now many of the parts are incorporating all of the pieces inside them.

I recently stumbled upon the Si4133 family from Silicon Labs in Austin, Texas.[1] This device has two on-board RF synthesizers that can operate in a selected range inside of the 750–1700 MHz range and an IF synthesizer that can go from 62.5–1000 MHz. The output from both of the RF synthesizers is not on at once. The part is designed to be able to jump from one to the other as you would in a multi-band handheld radio (phone) so they are multiplexed to a single output on the part. The last one programmed is sent out of the part through the multiplexer. The Si4133 family requires only an external inductor for each of the synthesizers for tuning and all the rest of the VCO, PLL, loop filter, etc., is all within the IC itself. The part also requires a reference frequency input that is used as the base oscillator for the PLL. A block diagram of the Si4133 is shown in figure 2.

When I saw this part, I started thinking about ways to use something like this for the microwave bands. If I could get the base oscillator provided to the XIN pin stable and could I program this, I could get a very stable base oscillator in the 1-GHz range that I could multiply up for a microwave LO. Coincidentally, the largest producer of microwave transverters in the United States, Downeast Microwave[2], is using a self-contained, roughly 1-GHz base oscillator as the starting point in all of its 2-GHz and up microwave transverters (of which I owned four, one for each of the ham bands between 2–10 GHz). The idea was really starting to take shape, but I had some more work to do.

Unfortunately, since the Silicon Labs synthesizers are designed to go into cellular phones and the like, there is an expectation that their frequency will be programmed by a microprocessor in the phone. In fact, the part has no non-volatile memory and powers up "dumb" and needs something to tell it what to do. I figured programming a microprocessor to load the synthesizer would be simple, though. My idea for a programmable oscillator is not entirely unique and there are a few oscillators that have capabilities like this floating around in the ham community today [3], but the predominant implementation stores the frequencies inside the micro and uses a dip switch to select among a few different common frequencies or is built for a single frequency. I wanted to be able to tune anywhere in the available range easily so I could use it for any microwave project.

Traditionally, I've done all of my micro programming like this using a serial port. I'd write a PC program to program the microcontroller using RS-232. However, RS-232 is falling out of favor in most circles, if not the amateur community, in favor of USB. I figured USB can't be *that* hard, right? I looked at some of the specifications and found that there is a lot of hidden complexity in USB. It allows a single hardware device to have a number of on-board virtual devices. For example, a single hardware device could have multiple serial ports or a single serial port and some sort of control interface, etc. With limited hobby time, I needed a way to cut through all of this complexity and quickly build a prototype that would get me what I needed. In the end, I wanted a PCB with a synthesizer that had a USB connector to program the microprocessor with virtually any frequency.

There are a few chips on the market that perform serial to USB, such as the FTDI

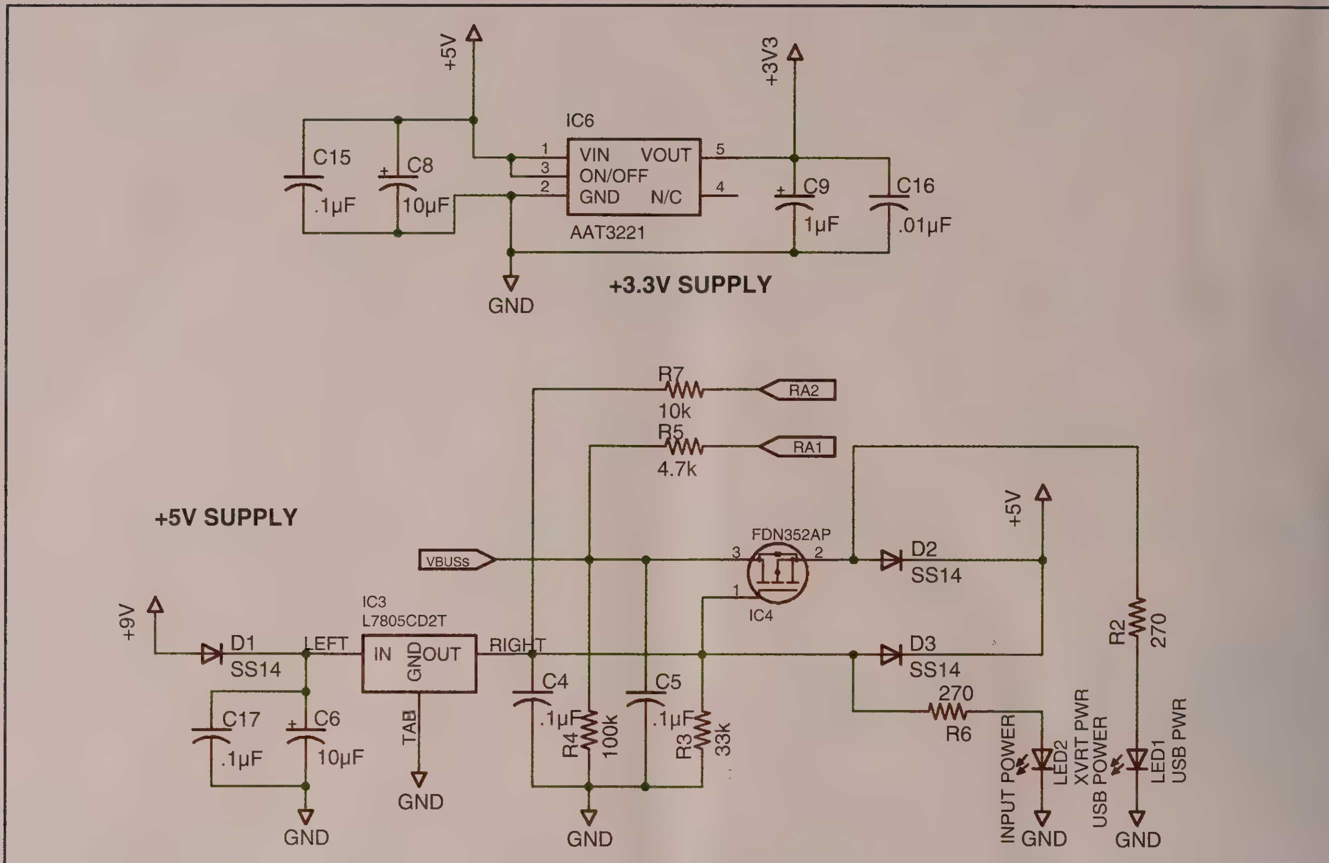

Figure 3. The apolLO I power-supply schematic.

chip[4], which hide the mechanics of talking to USB, and this was certainly one option. I was trying to keep the part count and the cost down, though, and I found that Microchip makes a small family of four parts that have on-board USB and require no additional external hardware (save the connector) to support USB[5]! What a windfall! I basically could hook a microprocessor to a synthesizer, add an inductor, some bypassing, and a USB connector and I would be in business! Well, it's never that simple, but it wasn't that far off.

The Final Design

The end design is very simple from a hardware standpoint and was almost more of an exercise in systems engineering, or putting the pieces together, rather than traditional electrical engineering. The power supply shown in figure 3 is mostly from a reference design provided by Microchip and generates a stable +4.5V supply from either the USB port (which has power) or from power input to the board. The +5V section has two main inputs—VBUS, which is the power from the USB port at 5V, and the input labeled +9V, which is intended to accept power from a transverter. The MOSFET shown as IC4 is designed to require current to be drawn from the power input pins rather than the USB in the case where power is applied to both inputs. To this I added a +3.3V supply for the synthesizer power.

Diodes D2 and D3 keep the power inputs separated. The outputs marked RA1 and RA2 provide information to the microprocessor so that it can tell the PC if it is drawing power from the PC or from an external source. This is done by the software in the PIC microprocessor. The 3.3V supply generates a low-current 3.3V source for use by the Si4133 synthesizer. Two LEDs are provided from the power supply and show when the board is powered by the USB port or by the external power input.

The synthesizer and the microprocessor are connected together through a set of data and clock lines that are used to load the synthesizer with configuration data. The bus line visible between the processor and the synthesizer has level-shifting resistors, since the processor is a 5V part and the synthesizer is a 3V part. Inductors external to the synthesizer control the range of the VCO internal to the synthesizer, which ultimately controls the synthesizer range. Although the VCO is capable of operating in a wide range of frequencies, 750–1700 MHz, only a narrow portion of this range can be tuned in any one implementation and the specific range is controlled by the external inductor.

The final input to the synthesizer is an external reference oscillator. This oscillator is used as a reference for phase locking inside of the synthesizer and should be in the range of 2–26 MHz. This reference sets the baseline for stability, accuracy, and phase noise of the final oscillator (see sidebar for details on these terms). While it might seem that we're back to the original problem of a stable oscillator—this time for our reference—there is a key difference: This oscillator can be on an arbitrary frequency. In other words, it does not need to be a direct multiple of our final oscillator frequency. Since there are many of stable 10-MHz reference oscillators available in the surplus market, this becomes a much easier problem.

A couple of examples of 10-MHz references are shown in figure 4. On the left is an Isotemp OCXO 134-10 with a stability of 0.01 ppm obtained for about $50 surplus, and on the right is a GPS disci-

Oscillator Characteristics

Stability refers to the ability of an oscillator to stay on the same frequency given changes in temperature, voltage or other environmental conditions. A stability of 1 ppm (one part-per-million, or 10-6) indicates that the oscillator will not move more than 1 Hz for each MHz of operating frequency over the specified temperature range. If an oscillator is multiplied in frequency for a higher operating frequency, the stability translates to a larger drift. For example, a 1-MHz oscillator with a stability of 1 ppm multiplied to 10 GHz could move up to 10 kHz across the specified temperature range. This is why oscillator stability becomes more important for higher operating frequencies. An oscillator that works well on HF may perform very poorly in the microwave frequencies.

Oscillators are also specified with a long-term stability value, sometimes known as **accuracy**. This aging number is expressed in ppm change over a period of time, such as 0.1 ppm/year. This number refers to the long-term drift that will occur as a natural part of crystal aging. The two main ways to combat this are to periodically net the oscillator back on frequency by comparing it against a standard and manually adjusting the frequency, or disciplining the oscillator to a more accurate reference such as GPS.

Phase noise is additional power in an oscillator output that is not on the fundamental frequency. All real oscillators have some phase noise, also called *noise sidebands,* which are a result of the design. For example, a synthesizer with a 1-MHz phase-detector update rate would have a noticeably higher noise level right at the carrier plus 1 MHz than would an oscillator with a 100-kHz phase detector update rate. PLL-based synthesizers have noise near the carrier as a result of the minor adjustments made to keep the carrier locked. Phase noise is expressed in dBc/Hz, or the number of dB down from the carrier the noise is, given a specific frequency away from the carrier. Thus, a phase noise of –70 dBc/Hz at 10 Hz means that there is noise that is 10 Hz away from the carrier and 70 dB below the carrier's power. The problem comes in when the oscillator is multiplied, because the noise gets multiplied at a rate of 20logN, where N is the multiplication ratio. Therefore, if we have a 1-GHz oscillator that is multiplied for a 10-GHz LO, the phase noise will increase by 20 times (20log10 = 20). Thus, the higher in frequency we go, the more noise we will have. This places a practical limit on how high in frequency we could use any given oscillator.

plined HP 58540A 10-MHz reference obtained for around $150. Additional options include surplus rubidium oscillators, other OCXOs, reference modules from cellular base stations such as the HP Z3801A, and others. The phase-noise and stability characteristics of these will vary, but most will be suitable for amateur operation up to 10 GHz or higher.

The final PC board, shown in figures 5 and 6, is designed as a drop-in replacement for the DEMI MICROLO local oscillator board. The MICROLO is the local oscillator used in the Downeast Microwave 2304-, 3456-, 5760-, and 10368-MHz transverters. There are a large number of these transverters in the field, and my personal interest was in adding a phase-locked oscillator to my DEMI transverters, so I designed the board to fit in the same space. This does not preclude using the board for other projects, of course.

Section 1 in figure 6 has the power supply mentioned earlier and the USB connection (on the left near the edge of the board). When powered via a transverter or other external power source, the green LED on the reverse of the board will be lit (LED2).

The second major section of the board is the microprocessor (µP); Section 2. The microprocessor's main purpose is to interface to the PC to collect information on how to program the synthesizer (frequency, reference frequency, PLL settings, etc.) and to program the synthesizer with this information. As mentioned earlier, the PIC 18F2550 was chosen because of its ability to interface directly to USB without other components and because of its low cost. The µP uses a 20-MHz clock which is used to derive the internal clock for the µP (48 MHz) and the USB clock (also 48 MHz for full USB 2.0 speed). While I could have derived the microprocessor clock from the reference input, I wanted to keep the two circuits completely separate to avoid any additional noise in the RF section. Also, I wanted to run the processor even when the reference failed or was removed. The 20-MHz CPU crystal allows the circuit to use full-speed USB 2.0 when communicating with the PC.

The PC software can query the board for configuration information as well as write configuration information to the RAM or EEPROM (non-volatile) in the microprocessor. On power-up, the microprocessor reads the local EEPROM containing the synthesizer configuration and writes this to the synthesizer. The synthesizer itself has no non-volatile memory for configurations.

The TCXO section (Section 3 in figure 6) accommodates one of three different TCXO pin-outs, or an external reference can be fed to the board. Most will want to use an external reference for two reasons: First, if you are going to run several transverters, it would be better to have a single external reference so only one frequency has to be adjusted. Second, the qualities of the larger OCXOs that are available surplus far surpass what you can get in a 5mm × 7mm TCXO. However, there may be situations, such

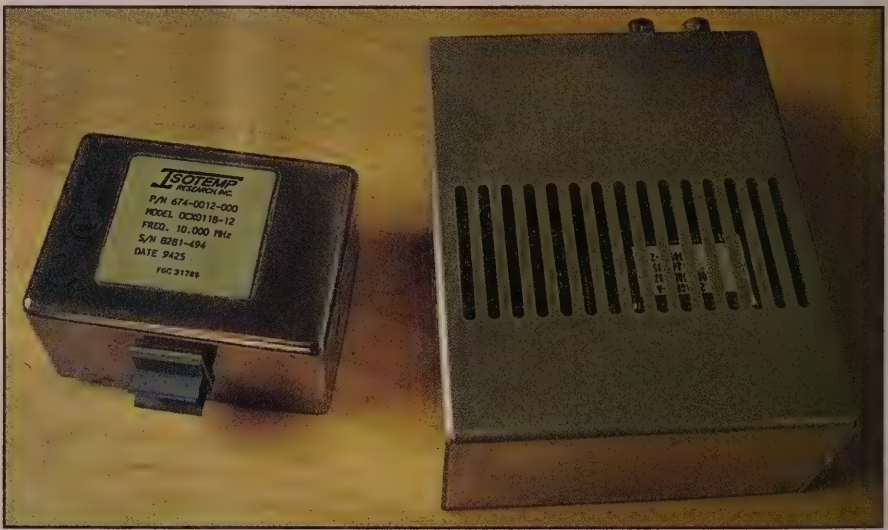

Figure 4. Two high-stability 10-MHz reference oscillators.

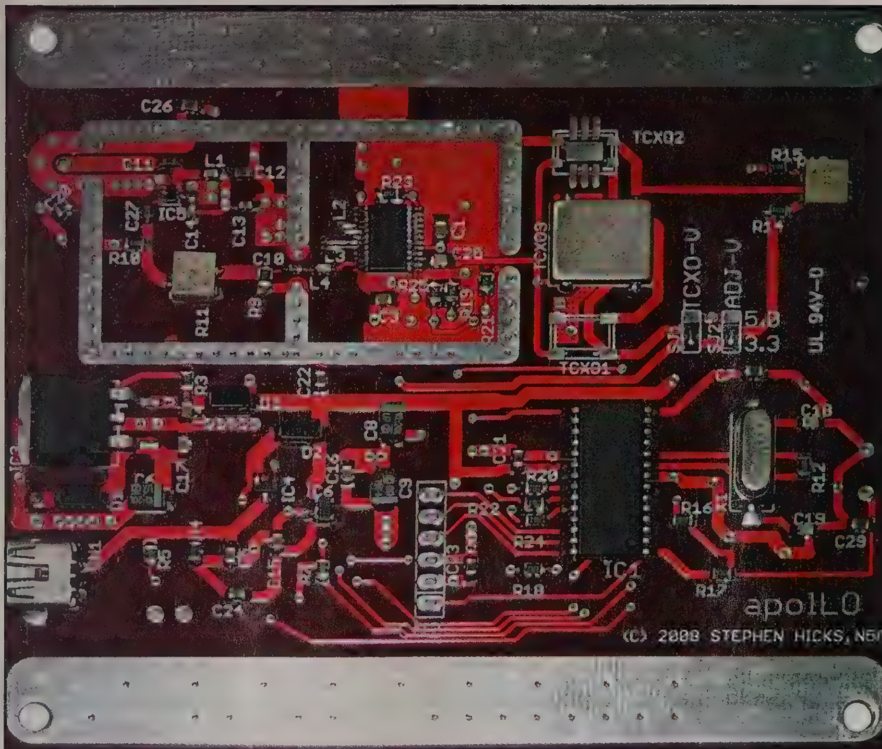

Figure 5. The final apolLO I fabricated PC board.

as a tripod-mounted 10-GHz transverter, in which some would prefer a TCXO in the transverter. There are also two sets of pads to select the TCXO voltage, and in the case of a VCTCXO, to select the voltage that is used to set the frequency. The external reference needs to provide a 0.5V to 3.6V peak-to-peak of reference signal (+7 dBm to +24 dBm). The Si4133 seems fairly forgiving, though, and I've run the board down to –10 dBm and it seems to perform well there also.

The Si4133 synthesizer is located in Section 4 of figure 6. Since the output of the Si4133, as low as –5 dBm, is low for use as an LO amplifier, I added an amplifier that can be seen in Section 5 of figure 6. The amplifier raises the signal level to +10 dBm or more. A pot is located in between the synthesizer and the amplifier to enable adjustment of the output power from the board.

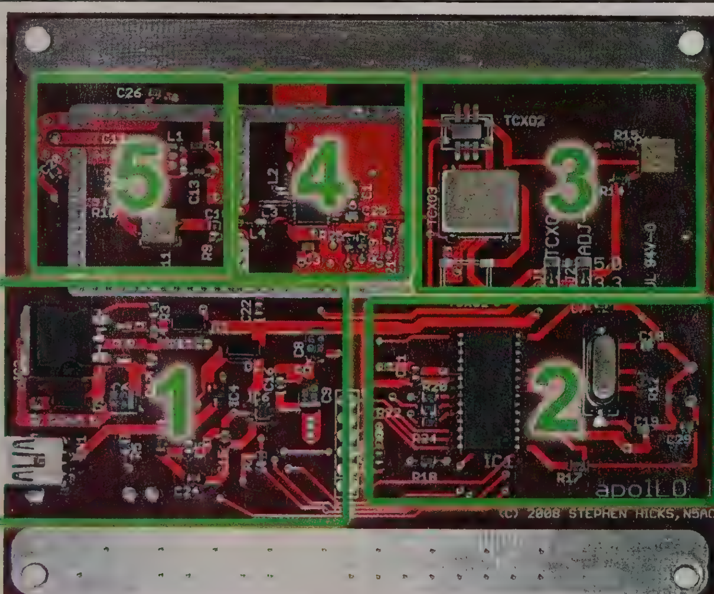

Figure 6. Major sections of the apolLO I PC board (annotated in text).

Detecting a Lock

The Si4133 synthesizer has an AUXOUT pin that can be used as a lock detect function. This is useful for determining if the frequency that has been programmed in the synthesizer is out of the VCO tuning range. When I first started working with the software, my expectations were that if my frequency was "good" and the synthesizer locked, I would get one voltage (+3V) on the pin, and if the frequency would not lock, I would get the other voltage (GND). The reality is a little different, though. As the synthesizer begins to have trouble locking, it loses lock for a short period then regains it, and this repeats over and over, generating all kinds of spurs and noise. If the AUXOUT line were simply connected to an LED, it might dim a bit when the synthesizer was losing lock, but this would likely be almost imperceptible. This was not a good solution.

What I decided to do instead was to sample the line 1000 times (this took less than 1 ms) and then look at the percentage of times when the synthesizer was reporting that it was locked. What I found was when it was in the operating region, the lock detect signal would be on 100% of the time. As the synthesizer lost lock, it would gradually go down to around 90% and then would fall fairly quickly down to around the 10% or less region. I decided to translate this into four states shown below:

State	Lock detect line % on	Lock LED
Locked	100%	Solid
Weak Lock	> 90%	Fast blink
Poor Lock	< 90%	Slow blink
Unlocked	0%	Off

I then translated this into an LED visible on the board as shown above. You generally would not want to run the synthesizer in any mode except when it is locked, but the LED can help in troubleshooting. When there is a weak lock, there is a carrier on the programmed frequency, but it will be discontinuous for up to 10% of the time, and outside of this time the synthesizer will be generating noise near the carrier.

Performance and Phase Noise

No discussion of a microwave oscillator would be complete without some basic

phase-noise discussion. A phased lock loop will always have some noise close in to the carrier, and this is the noise we are most concerned about for amateur radio use. Why? This noise can be audible when heard in the receiver if it is significant, and it can also create wideband noise near the carrier when we transmit. For example, if we are transmitting 200 watts on 2304.1 and the phase noise of our final LO is –50 dBc/Hz in the area of 1–10 kHz, this means that at 2304.105 MHz we will be creating noise that is 50 dB below our carrier (200 watts). This power level would be 200×10^{-5}, or 2 mW. This doesn't sound like a lot, but if your friend 10 miles across town is listening for a signal in the noise, your more local 2-mW signal is likely to be much more significant. Also, because it is noise, you would have just raised his noise floor significantly!

Since the multiplication of the oscillator increases the phase noise, there is a practical limit of how high in frequency any given oscillator should be used. What the real limit is depends on your situation. From a receive perspective, the question is: Can you hear a difference? In other words, does the phase noise raise your noise floor and make your operating difficult. From a transmit perspective, the question is about how clean your signal is. This equates to how many percent of your power you are transmitting on-channel versus how much is being generated as noise. If you are in an isolated area or are a mobile station, you probably can get away with a little noisier signal. On the other hand, if you are in a populated area and you are receiving complaints about QRM, you most likely have gone too far with your oscillator.

With all this talk about phase noise, the question of how much is too much arises. I don't have a really good answer for you, primarily because I have yet to use an oscillator for amateur radio that I felt was really objectionable. Most oscillators of the type we are talking about should be fine for use up to around the 24- or maybe even 47-GHz ham band. The phase-noise plot of the apolLO I board using an external surplus Datum 10 MHz reference is shown in figure 7.

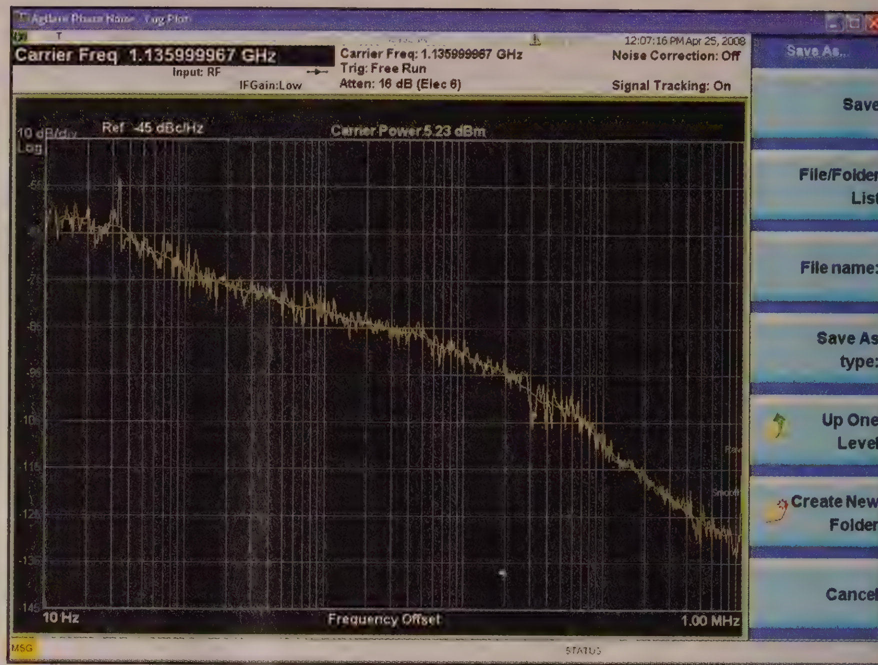

Figure 7. Phase noise of apolLO I at 1136 MHz with external 10-MHz reference.

Programming the LO

One of the unique features of the apolLO is the ability to program it. This makes it useful not only as a LO. but also as a good piece of test equipment. If you need an inexpensive signal source you can program and don't have a high-dollar signal generator, it might be a useful addition to your toolbox. The initial utility I created to program the apolLO is a Microsoft .NET application and will run on Microsoft Windows®. The utility, shown in figure 8, retrieves all of the typical model number and firmware version information from the LO as well as the current frequency of operation. It also allows direct access to registers inside the synthesizer to program the PLL divider values and set the PLL loop gain and which synthesizer is currently in operation (remember, there are two RF synthesizers inside the Si4133). This is, however, only one way to accomplish the programming.

Since many may not want to think about the calculations required to come up with the correct divider values to make the PLL function, I created a programming wizard that steps the user through the same process that you might go through if you were making the calculations yourself; instead the wizard makes them for you. The key pieces of information that the wizard needs to know to assist in the process are:

1. The frequency of your reference (generally 10 MHz).
2. The frequency of operation of your transverter (10368.1 MHz, for example).
3. The frequency of your IF radio (144.1 MHz, for example).
4. Whether you are using low- or high-side injection (typically, amateurs use low-side injection where the LO is below the operating frequency, but sometimes you might want to use high-side injection).
5. The multiplication factor to get you from a roughly 1-GHz intermediate LO up to your final LO (in the case of 10 GHz, often a factor of 9 is used so the final LO would be on 10,224 MHz, but our intermediate LO would be on 1152 MHz)

One of the wizard panels where custom transverter settings are entered is

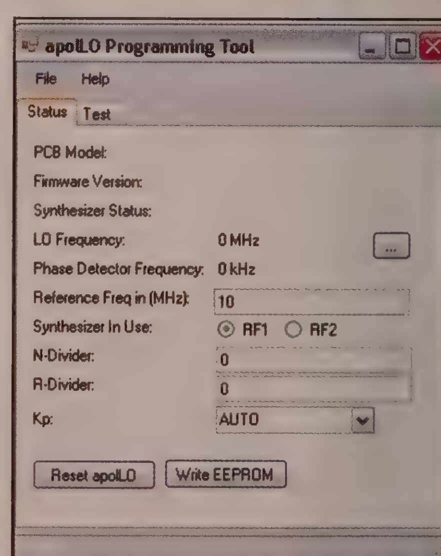

Figure 8. The apolLO programming utility for Microsoft Windows®.

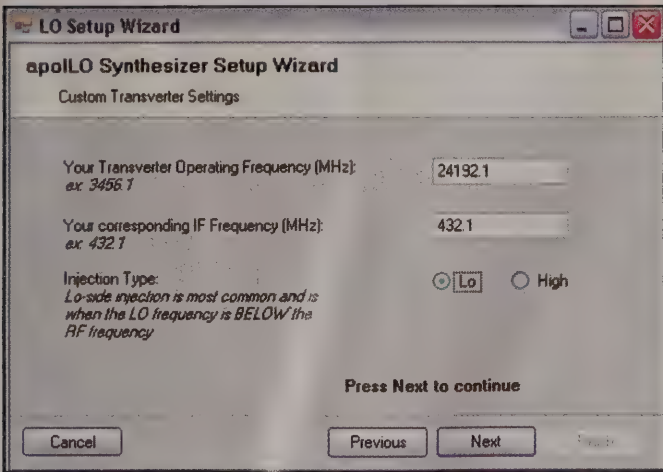

Figure 9. One of several panels in the apolLO programming wizard.

shown in figure 9. Here the user has entered 24,192.1 MHz for his transverter operation frequency (the 24-GHz ham band calling frequency) and 432.1 MHz for his transverter frequency and low-side injection. All of this ultimately ends in calculations that are shown in figure 10. Here you can see that a ×20 multiplier is selected and that the final LO frequency is 23,760 MHz. This will place the apolLO on 1188 MHz. When "Finish" is pressed on the wizard,the parameters are loaded into the LO and can then be written to EEPROM as a permanent change.

This provides a lot of flexibility so that several configurations can be tried in the shack to see what selection of parts, filters, etc., produce the best performance, all without building a new LO just to try the different configurations. It also gives rise to the possibility of keeping a "spare" LO on hand. If an LO in any transverter fails during a contest, it is a simple matter to program another one and plug it into the transverter.

Conclusions

From a functional standpoint, the apolLO was an easy project to build. The block diagram and conceptualization of the project was simple. As with any highly integrated design, though, there are a lot of details that have to be considered. The synthesizer itself has several parameters that can be tweaked, and software had to be written on both the PIC and the PC to make the whole package come together. The apolLO I has been a good project to experiment with oscillators, and it serves its function of replacing the aging MICROLO. The variable output, PC programmability, and ability to move the oscillator to a wide range of frequencies gives the design a lot of flexibility to be used in a number of different projects, not just as a replacement for the MICROLO.

I have just finished work on the second revision of the board, which includes the ability to shift to several different LO frequencies. My expectation is that this will help EME operators who need to operate on a number of different frequencies due to the range of allocations on the bands in each country. With this capability, the transverter could be moved from 2304 MHz to 2320 MHz to 2400 MHz with the flick of a switch. Since no additional components (crystals) are required, this is a very economical way to build a multi-frequency LO.

Kits, assembled, and bare apolLO I boards are available at: <http://store.n5ac.com>.

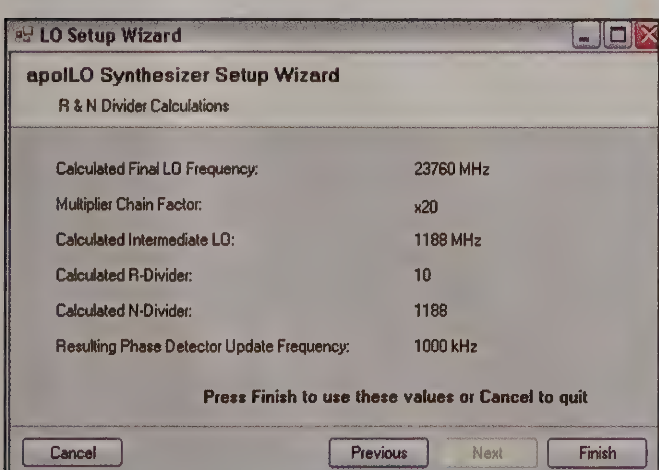

Figure 10. Final panel of the programming wizard setting apolLO parameters.

Notes

1. Silicon Labs, Austin, Texas: <http://www.silabs.com>.
2. Downeast Microwave: <http://www.downeastmicrowave.com>.
3. AD6IW microwave oscillator: <http://www.ad6iw.com/pll3.html>; and JWM Engineering: <http://www.jwmeng.com>.
4. FTDI Serial to USB chip: <http://www.ftdichip.com>.
5. Microchip 18F4550 family of microprocessors: <http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1335&dDocName=en010300>.

Low-Noise Pre-amplifiers for the 1.3, 2.3, and 3.4 GHz Amateur Bands

A goal for the microwave operator is to reduce the noise introduced by pre-amps. In this article G4DDK describes low-noise pre-amps for three of the popular microwave amateur bands.

By Sam Jewell,* G4DDK

Invariably, 1296-MHz moon-bounce (EME) requires the use of a very-low-noise pre-amplifier (LNA) to receive the weak signals that are often encountered. This is especially true when only a small TVRO dish can be used as the antenna. I have successfully used a 7.5-foot KTI TVRO dish for both 1.3- and 2.3-GHz EME using the pre-amplifier designs in this article.

My initial EME activity was with the well-known 1.3-GHz LNA design published by Tommy Henderson, WD5AGO[1], whilst the 2.3-GHz LNA was a modification of a design by Al Ward, W5LUA[2].

Following requests for help and information. I made a number of PC boards for radio amateurs in Europe. In general these worked well, which is a testament to the solid designs from Tommy and Al.

Because of ongoing demand and difficulties obtaining new ATF10135 MESFETs (metal epitaxial semiconductor field effect transistors) for use in the second stage of the 1.3-GHz pre-amplifier, I decided to investigate an alternative second-stage device. I also decided to house the pre-amplifier in a readily available tin-plate box. The new design achieves a lower 1.3-GHz noise figure, and higher gain than the original pre-amplifier design.

Noise-figure and gain measurements at various microwave events in the UK, The Netherlands, Germany, as well as at Central States VHF Conference 2007 have shown that a stable, repeatable, noise figure of around 0.25–0.27 dB, with an insertion gain of 36 dB, is achievable with the 1296-MHz version.

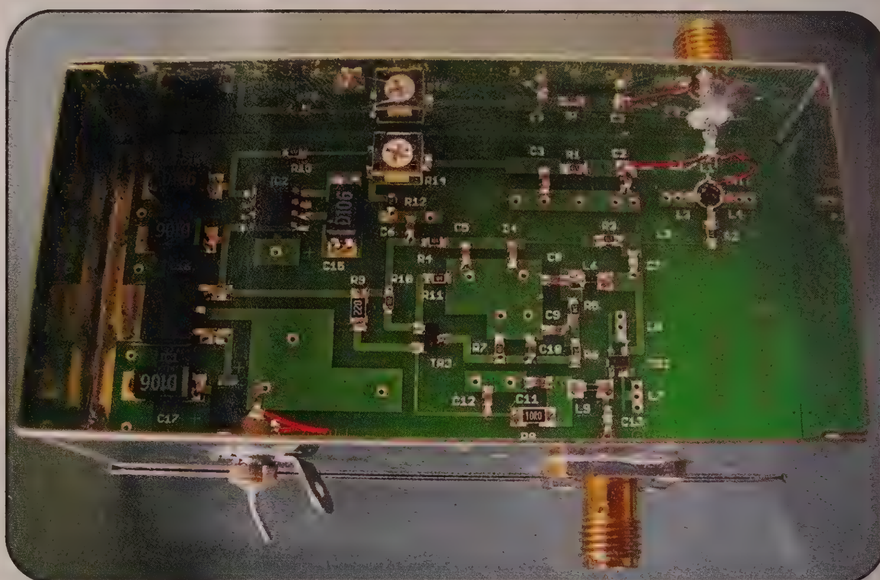

Photo A. The completed 2.3-GHz version of the LNA.

It was apparent that the same pre-amplifier board also had the potential to work at 2.3 GHz, especially with the air-supported input components as used in Al's design. This necessitated some component-value changes to optimize performance at the higher frequency. After installing components with the calculated values (and some inspired empirical substitution!), the result was a noise figure of around 0.35 dB and an insertion gain of about 26 dB. The reason for lower gain at 2.3 GHz is partly due to the second-stage device and the use of a non-optimum microstrip line, which is part of the 1.3-GHz design. However, for EME work, even an insertion gain of 26 dB may be enough to eliminate the usual second pre-amplifier unit.

Further work showed that the pre-amplifier would also produce an acceptable noise figure and gain in the 3.4-GHz amateur band. A 3.4-GHz noise figure of between 0.5 and 0.55 dB with an insertion gain of around 28 dB is easily achieved.

Versions of the pre-amplifier have been successfully tuned for use at 1090 MHz, 1240–1296 MHz, 1420 MHz, 2200–2290 MHz, and 2302–2320 MHz, all with excellent results. Work has commenced on a 432-MHz version of the pre-amplifier.

Circuit Description

The circuit schematic is shown in figure 1.This is the same for all three versions of the pre-amplifier. Component values are shown in Table 1. Where component values are different for each of the various bands, these are shown in Table 2.

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This is an update of the paper presented at the Florence 2008 EME Conference.

Two different low-noise GaAs FETs have been specified for use in the 1.3-GHz pre-amplifier. The NE32584C gives the lowest noise figure, but these are no longer available from NEC. However, there are still large stocks of the NE32584C and other package variants available as surplus stock in the U.S. and Europe.

The Avago ATF36077 has been shown to work extremely well in the TR1 position, but it has a marginally higher noise figure at 1.3 GHz compared to the NE32584. The NE32584 is therefore the preferred device for 1296-MHz EME. The second-stage device is an Avago ATF54143 in all cases. I have been unable to get the newer NE3210 HEMT to work well in the first stage at these frequencies.

The input circuit consists of a "T" match with suitable low-loss capacitors and inductors. These components are air supported, rather than soldered to PC board pads, in order to keep losses due to parasitic strays to a minimum.

Low-noise matching is achieved by careful adjustment of the spacing of the turns of L1. Adjustment is critical in order to achieve the very lowest noise figure. This will not coincide with maximum gain. In these designs lowest noise always occurs on the high-frequency side of the maximum-gain frequency.

Input impedance match is improved by the use of first stage GaAs FET source series inductance. This is already designed into the PC board, and results from the inductance of the leads of TR1, so you don't need to worry about tuning this parameter. Since the source leads of the ATF36077 are broader than those on the NE32584, the inductance is lower and consequently the feedback is less. This results in a slightly worse input return loss. When tuned for lowest noise figure with a 50R source, the input return loss of the pre-amplifier will not affect the achievable system noise figure as long as the antenna is also a good 50R source. However, poor input return loss does lead to a greater uncertainty of the actual noise figure when measurements are made. This is often the reason for some very disappointing and even optimistic results when using otherwise excellent pre-amplifier designs.

Negative bias for TR1 is provided by an ICL7660 DC-DC converter. R14 allows a range of adjustment of gate bias voltage which will lead to a consequent change in drain current.

Active bias was chosen for TR2, as the drain current is set at 65 mA to achieve a good dynamic range. At this elevated current I felt that active bias would help to maintain circuit performance.

The pre-amplifier uses a 5-volt, 500-mA regulator that uses a surface-mount 78M05 regulator soldered to the PC board ground-plane heat sink. A TO92 packaged 78L05 will not supply enough current without over-dissipating.

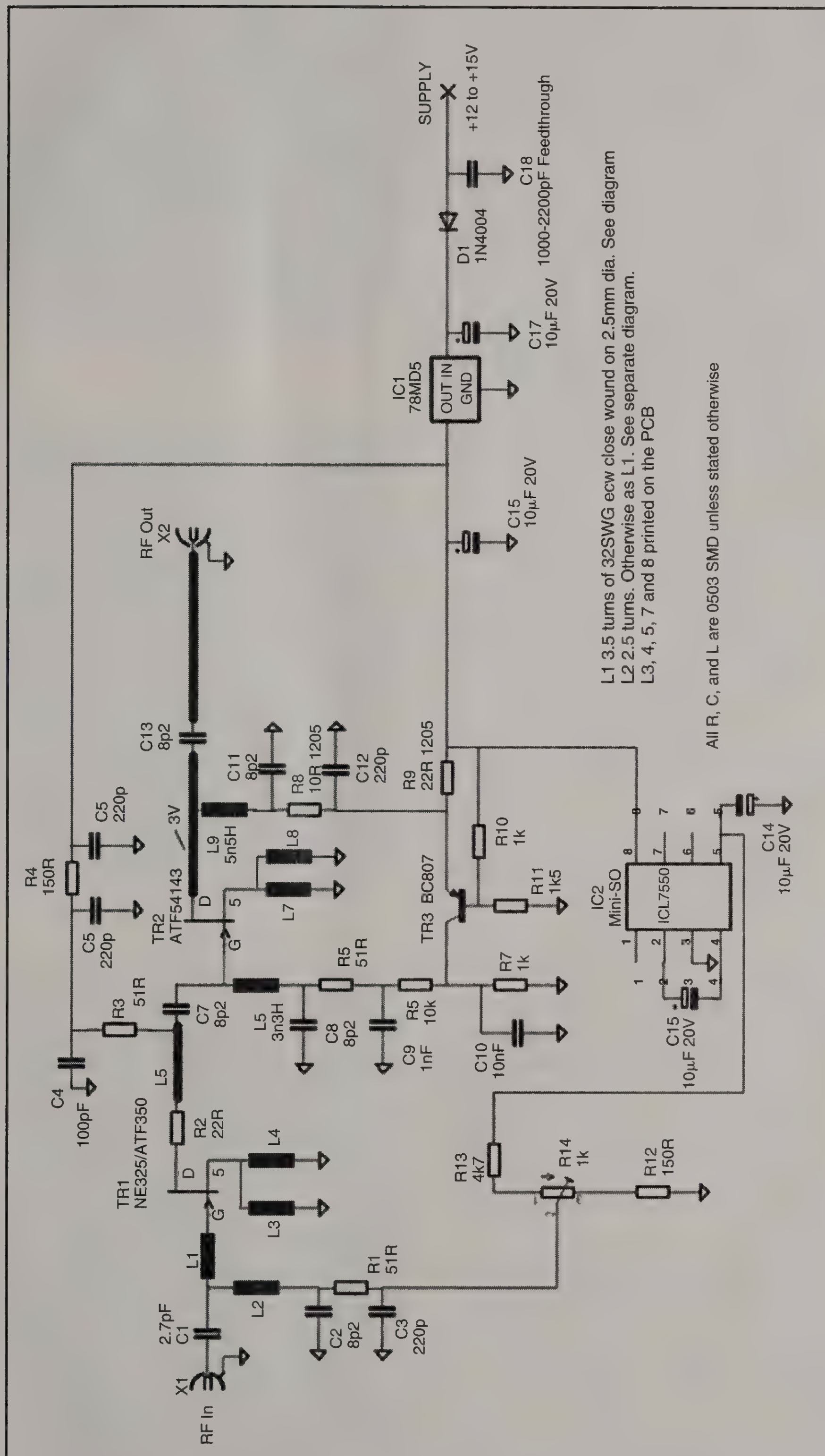

Figure 1. Circuit schematic of the 1.3-GHz LNA. Values for the 2.3- and 3.4-GHz versions are given in Tables 1 and 2.

D1 is there to ensure that an accidental reversal of the supply doesn't destroy the pre-amplifier.

Noise and gain matching of the 2.3-GHz and 3.4-GHz version of the pre-amplifier necessitates a change of C1, L1 and L2 inductors at the input, L9 in the drain of TR2, and the coupling capacitors C7 and C13. It also uses the ATF36077, and not the NE32584, in the first stage, although an ATF54143 is still used in the second-stage position.

With the very high gain that is achieved in the 1.3-GHz version of the pre-amplifier stability can be a problem due to the compact construction that has been used. A range of RF absorber materials was tried by gluing several different types to the lid of the tin-plate box, in turn, and noting the results. Eventually ARC DD-10017 (2 mm thick) silicone magnetic absorber tile material was selected for use in the 1.3-GHz and 2.3-GHz pre-amplifiers, where it has proven to be very effective at suppressing unwanted coupling and aiding stability. At 3.4 GHz it has been found necessary to use ARC LS-10055 Urethane foam (3.2 mm thick), since the coupling mechanisms change considerably from 1.3 GHz to 3.4 GHz.

Part	Value	Package
C1 – 1.3 GHz	See table 2	SMD0805
C1 – 2.3 GHz	See table 2	SMD0805
C1 – 3.4 GHz	See table 2	SMD0805
C2, C8, C11,	See table 2	SMD0603
C7, C13 - 1.3 GHz	See table 2	SMD0603
C7 , C13 - 2.3 GHz	See table 2	SMD0603
C7 , C13 – 3.4 GHz	See table 2	SMD0603
C3, C5, C6, C12	220 pF	SMD0603
C4	100 pF	SMD0603
C9	1 nF	SMD0603
C10	10 pF	SMD0603
C14, C15, C16, 17	10 μF 20V	Tantalum
R1, R3, R5	51R	SMD0603
R2	22R	SMD0603
R4, R12	150R	SMD0603
R6	10k	SMD0603
R7, R10	1k	SMD0603
R11	1k5	SMD0603
R14	1k	SMD trim resistor
R8	10R	SMD1206
R9	22R	SMD1206
R13	4k7	SMD0603
TR1	See table 2	—
TR2	ATF54143	SOT343
TR3	BC807	SOT23
IC1	78M05	D-Pak
IC2	ICL7660	SOIC-8
D1	1N4001	SMD
L1/l2	0.28-mm dia. enamel-covered copper wire	See diagrams
L3, L4, L5, L7, L8	Printed on PCB	—
L6	3n3	SMD0603
L9 – 1.3 GHz	See table 2	SMD0603
L9 – 2.3 GHz	See table 2	SMD0603
L9 – 3.4 GHz	See table 2	SMD0603
Box	4 piece tinplate	74 mm × 37 mm × 30 mm
Absorber – 1.3 and 2.3 GHz	See table 2	30 mm × 50 mm
Absorber – 3.4 GHz	See table 2	30 mm × 50 mm
PCB	VLNA Issue B	72 mm × 34 mm

Table 1. Component list for the 1.3, 2.3, and 3.4 GHz LNA.

Construction

Full construction details, alignment, and tips are shown on my web page at <www.g4ddk.com>.

The preamplifier is built on a double-sided 1.6-mm thick, FR4 printed circuit board. The PC board artwork is shown in figure 2. Component layout is shown in figure 3.

The PC board is seam-soldered into the tin-plate box. The same board is used for the 1.3-, 2.3-, and 3.4-GHz pre-amplifier variants. The only components that need to be changed when optimizing the band of operation are TR1, L1, L2, L9, C1, C7, and C13 (and the absorber tile material for the 3.4-GHz version). See the component list for details.

Except where indicated, 0603-size surface-mount components are used on the board in order to minimize component parasitics. This has proven most successful, and it is a very good reason to move towards using 0603- or even 0402-size parts in all designs above 1 GHz.

Input and output RF connectors are both SMA. EME operators may prefer to use an "N" type for the input. As long as this has the smaller size flange, it can be fitted within the 30-mm height of the box. The connectors can be fixed to the box by drilling holes and using small screws with nuts, or by soldering the connector flange to the tin box.

The input connector is mounted 10 mm above the track side of the PC board and in-line with the gate of TR1. The output connector is mounted with its spill soldered direct to the pre-amplifier RF output track.

The tin-plate box needs to be marked as indicated on my web page with holes drilled to accept the input and output sockets as well as the feed-through capacitor.

It is advisable to solder the four 10-μF tantalum capacitors and the 78M05 voltage regulator onto the board before this is soldered into the tin-plate box, as the capacitors near the 78M05 voltage regulator will be found difficult to solder afterwards due to their proximity to the sides of the box. Take care to observe the correct polarity of the tantalum capacitors.

Band	L1	L2	C1	C7, C13	L9	TR1	Absorber
1.3 GHz	3.5 turns	2.5 turns	2.7 pF	8.2 pF	5.6 nH	NE32584/ATF36077	ARC DS10017
2.3 GHz	12-mm hairpin	11-mm straight	3.3 pF	4.7 pF	3.3 nH	ATF36077	ARC DS10017
3.4 GHz	9-mm hairpin	11-mm straight	1 pF	4.7 pF	3.3 nH	ATF36077	ARC LS10055

Table 2. Component changes for the three amateur band versions of the LNA. All other values are the same for the three amateur band versions of the pre-amplifier.

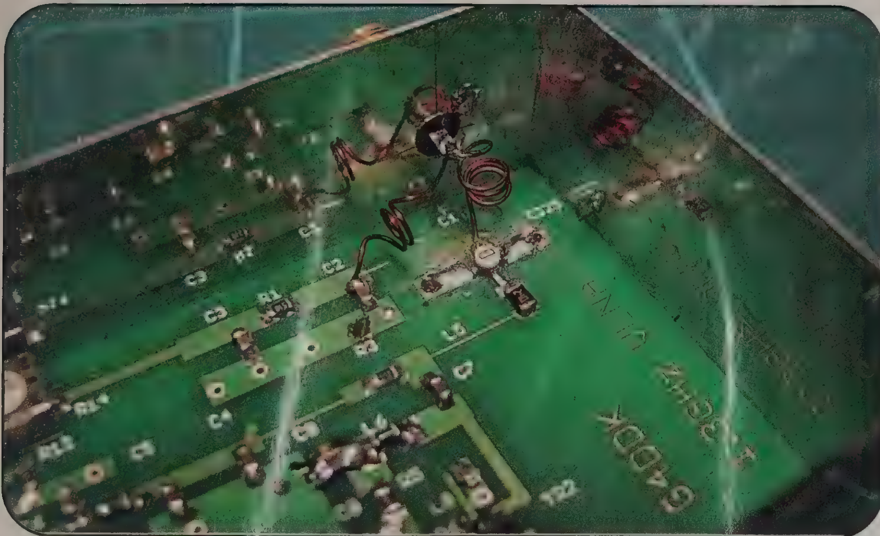

Photo B. Input coil details of L1 and L2 for the 1.3-GHz version.

Photo C. The 2.3-GHz VLNA L1 and L2 hairpin loop details.

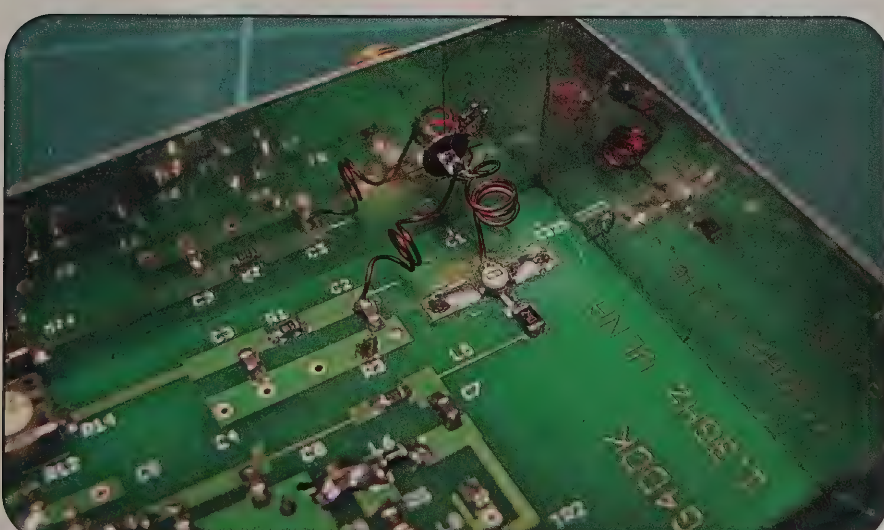

Photo D. The 3.4-GHz LNA L1 and L2 input hairpin loop details.

Use only small-gauge solder (U.S. 30-gauge size; nothing larger) and a fine-pointed, small soldering iron to solder all the components onto the board. *Regular 24-gauge solder is guaranteed to make a mess of the board!*

Solder C1 onto the spill of the input connector, being careful not to overheat the capacitor, as it could crack and this is not always obvious. Solder L2 so that one end is on the track pad, as shown, and the other end is carefully soldered to the free end of C1. Solder L1 so that the lower end lead is free to be soldered to TR1 gate. Winding details for L1 and L2 are shown on the schematic diagram and orientation of L1 and L2 can be seen in photo B.

Solder in the two GaAs FETs *after* the initial setting up.

Initial Setting Up

Check that there is +5V at the output of IC1 and that there is –5V at the output of IC2. Solder in TR1 and TR2 when you are happy that the supply voltages are correct. Disconnect the supply first, of course!

Alignment

Adjust R14 for 2V on the drain of TR1.

1.3 GHz details. With L1 still close

wound, measure the noise figure. Now carefully bend the top turn up and away from the remaining turns. The turns should be spaced as shown in figure 2. Re-measure the noise figure. It should be very low. Now *carefully* adjust the spacing of these coil turns for the lowest noise figure. Care here will be rewarded. There *may* also be some advantage in *slightly* re-adjusting L2 coil spacing. Use only the recommended wire size. Larger gauge wire may crack C1 whilst L1 is being adjusted. Be warned!

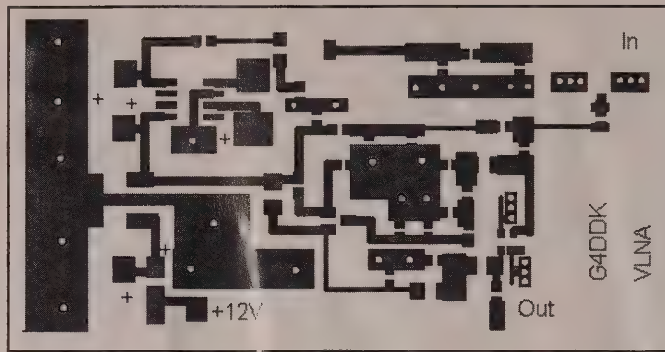

Figure 2. VLNA PCB. 74×37×1.6 mm FR4 double-sided.

Put the RF absorbent material inside the lid of the tin-plate box. Putting the lid in place should not result in any increase in noise figure or loss of gain.

Slight readjustment of TR1 bias, with R14, may produce a slightly lower noise figure.

2.3 and 3.4 GHz details. There should be no need to adjust L1 or L2 in the 2.3- or 3.4-GHz version of the pre-amplifier. As long as L1 is the correct length and oriented as shown, it should be as good as it gets. Adjustment of the drain current with R14 is the only variable left.

Photos C and D show the input coil/hairpin positions.

Always check <http://www.g4ddk.com> for the latest building instructions for the LNA before commencing construction of the pre-amplifier.

Results

A number of the pre-amplifiers are now in regular use on EME. In particular, the 1.3-GHz pre-amplifier has been popular with small-dish EME operators. The 2.3-GHz pre-amplifier has proven to be competitive with other designs in use in both EME and terrestrial operation. Few 3.4-GHz pre-amplifiers have been built. Could this could be a result of the lesser activity on this band?

Initial concerns about using 0603-size SMD parts have not been realized. The biggest problem seems to have been losing the small parts on the typical radio amateurs work bench! 0603-size parts are currently the most economic SMD size parts to purchase from component suppliers (at least in the UK) and an extremely wide range of parts is available.

A couple of incidents of poor noise figure have been reported. This tends to manifest itself as a noise figure (on 1.3 GHz) of about 1–1.5 dB and a gain in the low 20-dB range. When this has been investigated, it usually was found to be due to instability, with an oscillation around 15 GHz. The reason for this has not been finally resolved, but is easily cured by cutting a small (2 mm × 3 mm) piece from the absorption tile and gluing this over the 22R (R2) resistor in the drain of TR1.

Future Work

The existing PC board is well-suited to be used in the 430-MHz band. However, simulations with Microwave Office have shown that instability may be a problem. A suitable solution is currently being investigated and the results will appear on my web page in due course.

It seems unlikely that the present PC board and circuit will be usable at 5.7 GHz and above, although this is not ruled out with a change of TR2 and a few other small circuit modifications.

References

1. “Low noise two-stage amplifier for 23 cm,” WD5AGO design presented in the *Proceedings* of the 1999. Microwave Update, Plano, Texas.

2. “Low noise amplifier for 2404 MHz using the HP PHEMT device ATF36077” WB5LUA (now W5LUA) design presented in the *Proceedings* of the 1994 Microwave Update, Estes Park, Colorado.

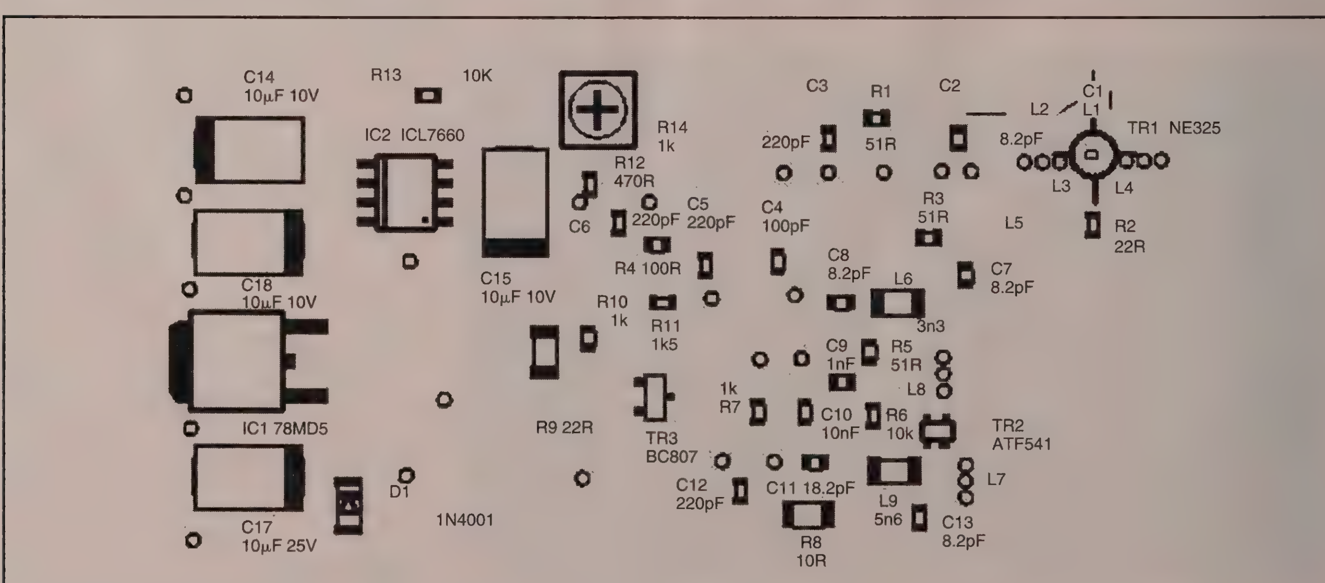

Figure 3. Component overlay for the LNA.

Predicting 6-meter *F2* Propagation

K9LA introduces a method for predicting 6-meter *F2* propagation for any path, any phase of a solar cycle, any month, and any time of day.

By Carl Luetzelschwab,* K9LA

In his article "Predicting Transatlantic 50-MHz F-Layer Propagation" in the March 1993 issue of *QST*, Emil Pocock, W3EP, derived a statistical plot that forecasted transatlantic 6-meter propagation from New England to Europe via the *F2* region. The plot was based on data for the months of November, December, January, and February around solar maximum at the optimum times of day.

The purpose of this article is to introduce a method to predict 6-meter *F2* propagation for any path, for any phase of a solar cycle, for any month, and for any time of day. If you're a seasoned 6-meter operator, more than likely you won't need any help with predicting 6-meter *F2* propagation. However, if you're new to 6 meters or in an unfamiliar location, you may find this method useful.

The method will use one of our HF propagation prediction programs, specifically VOACAP (Voice of America Coverage Analysis Program), which is the Voice of America version of the well-respected IONCAP (Ionospheric Communications and Analysis Prediction) program. For a brief tutorial of VOACAP, including download instructions, visit <http://mysite.verizon.net/k9la/id9.html> and read the file "Downloading and Using VOACAP."

An Initial Run with VOACAP

Since VOACAP is an HF prediction program (2–30 MHz), we suspect it won't do very well on 6-meter paths. We can verify this by running a prediction from North America to Europe during the good days of November 2001. Then from observations during this period in "The World Above 50 MHZ" column by W3EP in the February 2002 issue of *QST,* we can evaluate VOACAP's 6-meter performance. Figure 1 shows the path under analysis.

We'll use Method 30 in VOACAP at 1600 UTC for a path from western Pennsylvania to Germany. Because our propagation prediction programs were developed based on the correlation between a smoothed solar index (either smoothed solar flux or smoothed sunspot number) and monthly median ionospheric parameters, we'll run the prediction using the November 2001 smoothed solar flux of 194 (from the plot "ISES Solar Cycle F10.7cm Radio Flux Progression" at <http://www.swpc.noaa.gov/SolarCycle/>.

Figure 1. The western W3 to DL path.

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VOACAP predicts the monthly median MUF (maximum usable frequency) for our W3-to-DL path to be 37.2 MHz (this is the value given in the left-most column of the results). We can determine the distribution about the median MUF by using the tables of MUF variability in our ionospheric literature (for example, in the booklet "Predicting Statistical Performance Indexes for High Frequency Ionospheric Telecommunications Systems," Technical Report 1-ITSA 1, 1966).

From this we see that on 10 percent of the days of November 2001 (three days) the actual MUF is predicted to be as high as 41.3 MHz. This also says the probability of the MUF being high enough for 50.1 MHz is zero. However, there was 6-meter *F2* propagation in November 2001, as noted in the aforementioned "The World Above 50 MHZ" column, and thus our initial suspicion that VOACAP doesn't do well on 6 meters is confirmed.

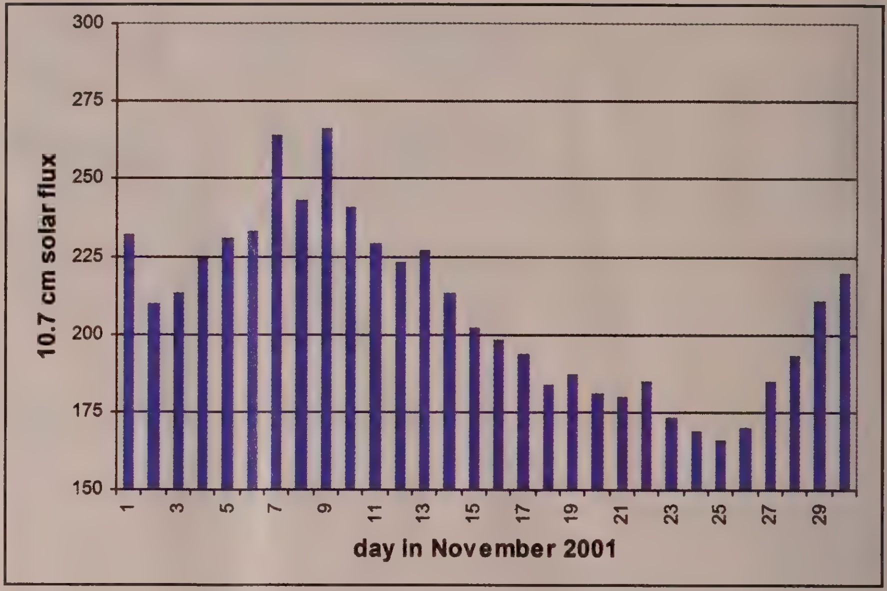


Figure 2. Daily solar flux for November 2001.

A Solar Index Issue

One problem with VOACAP for 6-meter predictions (and with any of our other HF prediction programs, for that matter) is tied to the solar index used. The use of the heavily-averaged smoothed solar flux value of 194 for our prediction belies the fact that the solar flux was significantly higher right before November 11 through November 19, the period when most of the 6-meter openings occurred. Figure 2 plots the daily solar flux for November 2001.

Thus, it appears that we need a shorter-term solar flux measurement for input to VOACAP. We could use daily solar flux, but unfortunately the state of the ionosphere does not correlate well with daily solar flux. Figure 3 shows this by plotting the daily MUF over the Goose Bay, Labrador ionosonde (which is along the path from western Pennsylvania to Germany) and the corresponding daily solar flux for November 2001.

The R^2 value in the upper right-hand corner of figure 3 tells us how well the two parameters (daily MUF and daily solar flux) are correlated. An R^2 value of 0.00 indicates no correlation, and the data points would be widely scattered about the red regression line (as they are in figure 3). An R^2 value of 1.00 indicates perfect correlation, and all the data points would fall right on the red regression line. With an R^2 value of 0.2679, we confirm that there is little correlation between MUF and solar flux on a daily basis. For example, a solar flux of around 195 resulted in a MUF as low as 40 MHz on one day and as high as 46 MHz on another day.

The result of figure 3 is typical of results using data from other months and other years. Even bringing geomagnetic field activity into the picture (through a *K* or *A* index) doesn't improve the correlation to any significant degree on a daily basis.

What this tells us is that there are other processes that ultimately determine the amount of *F2* region ionization in the ionosphere. Solar flux is certainly the instigator (strictly speaking, solar flux at a wavelength of 10.7 cm is a proxy for the true ionizing radiation at wavelengths between 10–100 nm), but geomagnetic field activity on a longer term basis and events in the lower atmosphere coupling up to the ionosphere also play important roles. This is why our propagation prediction programs were developed as monthly median models using a smoothed solar index. The developers never meant them to be used for daily predictions, as they well understood the scatter seen in figure 3.

Path Geometry Issues

The other problem with VOACAP for 6-meter predictions (and again with any of our other HF prediction programs) is

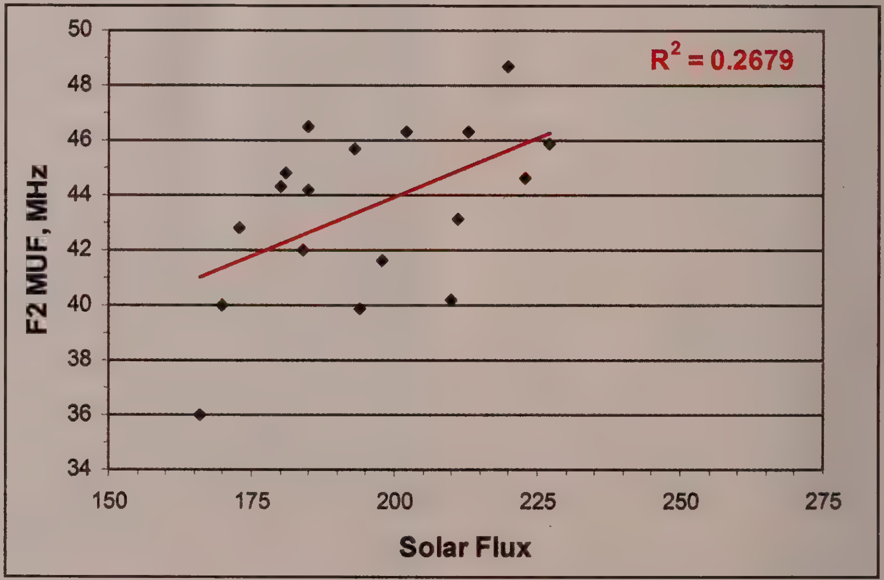


Figure 3. Daily MUF versus daily solar flux for November 2001.

path geometry issues. There are three fundamental assumptions under suspicion for 6-meter propagation.

The first assumption is that hop lengths are 3000 km. That value is a good compromise for the 3–30 MHz HF range, with shorter distances at the lower frequency end (because there's more refraction at the lower frequencies, giving shorter hops) and longer distances at the higher frequency end up to the generally accepted HF limit of 4000 km. We therefore would expect that 6-meter propagation could have hops greater than 4000 km, with resulting higher MUFs, since the electromagnetic wave would graze the ionosphere at an even lower angle of incidence (W3EP cited two papers discussing propagation above 30 MHz with hops significantly greater than 4000 km in his March 1993 *QST* article). There's also evidence from other QSOs suggesting that propagation on 6 meters at times can involve ionosphere-ionosphere modes (chordal hops or ducting), which also results in higher MUFs.

The second assumption is that an electromagnetic wave follows a great circle path. This ignores the fact that some deviation from the great circle path can occur, which is due to an encounter with the ionosphere where MUFs are higher (generally at a more southerly latitude).

The third assumption is that pure refraction occurs. This ignores scatter-type paths (VOACAP does have an over-the-MUF algorithm that assumes scatter, but it doesn't help our efforts, since VOACAP only goes to 30 MHz). Although scatter-type paths incur additional losses, the amount of *D* region absorption on 6 meters is minimal. Thus, 6 meters is more forgiving than the HF bands, and it can tolerate more loss due to a scatter mechanism.

Forcing VOACAP to Agree with 6-meter Observations

We know that the "stock" VOACAP does not do too well with 6-meter predictions, and we also know the issues that appear to cause this – the use of the heavily averaged smoothed solar index and assuming only refraction over 3000-km hops along the great circle path.

For the solar index issue, we'll use a 7-day average of solar flux. That better represents what the ionosphere is doing short term (it's not perfect, but it is better than the use of daily solar flux). For the path geometry issues, we'll apply a multiplying factor (derived from W3EP's 1993 *QST* article and from observations in W3EP's February 2002 column) to the *F2* region through the "foF2 Fprob" option in VOACAP's setup menu. Using a 7-day average of solar flux certainly gets VOACAP closer to 6-meter reality, but the multiplying factor is still needed to account for "non-HF" modes on 6 meters.

The Method to Predict 6-meter Propagation

The development of the method is mostly based on sound physical principles, but I readily admit some of it is akin to "arm waving," since our understanding of propagation in the ionosphere is statistical in nature; it is not deterministic. The method can be summarized in four steps:

Step 1: Determine the short-term solar flux by taking the 7-day average prior to the desired period.

Step 2: Change the multiplier in the "foF2 Fprob" option in VOACAP from 1.00 to 1.20.

Step 3: Run Method 30 in VOACAP using an operating frequency of 30 MHz (VOACAP defaults to 30 MHz if you try to input 50 MHz, but that's OK, as we're really not concerned with any operating frequency we input). Note the MUF in the *first* column of data (ignore the data in the 30 MHz column).

Step 4: If the MUF in the *first* column is around 45 MHz, you should start looking for 6-meter *F2* propagation. The higher the MUF with this method, the higher the probability will be for 6-meter *F2* propagation.

Geomagnetic Field Activity

Along with extremely high solar flux comes the likelihood of geomagnetic-field activity. In general, the *F2* region will be depleted when this occurs, so high solar flux values will not necessarily always imply 6-meter propagation. In essence, this method will work best when the geomagnetic-field activity is either low to start with or returns to quiet conditions.

Acknowledgements

I would like to thank Emil Pocock, W3EP, for his review of and comments on this article. ■

2500 Miles with JUST a Loop?

Although the lowly VHF/UHF loop antenna offers zero gain in all directions, it is the hot ticket on SSB and CW!

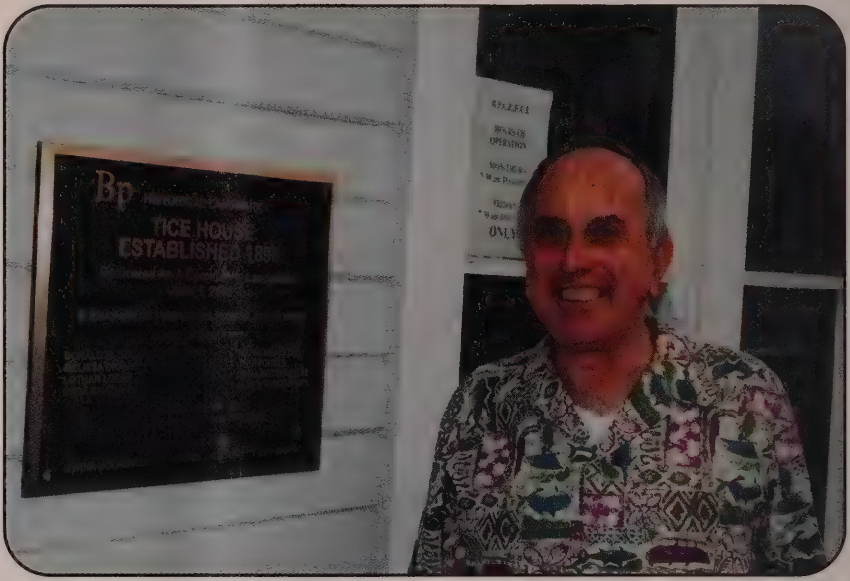
By Gordon West,* WB6NOA

Count the horizontal omnidirectional loop antenna *in* for your VHF/ UHF mobile/portable station. The tiny loop might also bridge the Pacific (or Gulf, Midwest, or East Coast) from a hidden attic installation.

"Every July, like Pacific Coast clockwork, a Pacific high builds in between California and Hawaii," comments Julian Frost, N3JF. "Our first California-Hawaii opening this year developed on June 18th, and signals were so strong that I could easily hear the KH6HME beacon coming in on my attic loop, spanning 2500 miles!"

Often homeowner associations ban any sort of visible outside ham antenna, but a single loop might double as an over-the-air outside digital TV antenna, and can easily hide inside an attic for some exciting horizontally-polarized VHF/ UHF contacts:

50.125 MHz calling SSB
144.200 MHz calling SSB
432.100 MHz calling SSB
1296.100 MHz calling SSB



Paul Lieb, KH6HME, the tropo voice of Hawaii. (All photos by the author)

Loops Plus Weather Equals Success

Tropospheric ducting is a weather phenomenon. Loop antennas, horizontally polarized, eliminate 10- to 20-dB cross-polarization loss if you are trying to work VHF/UHF SSB and CW from a monster collinear vertical or that big vertically polarized beam.

When weather conditions associated with a stationary high-pressure system form, "tropo" signal enhancement can be so pronounced that a 0-dB gain horizontally-polarized loop can span over the water to a distance greater than 2500 miles!

The Loop

The horizontal loop antenna is a half-wave dipole formed in a circle to offer no-null performance in all directions. There are multiple commercial manufacturers of single-band VHF/UHF loops (see References), including one unique loop that offers 2-meter *and* 432-MHz performance—one loop, two bands. This is handy when operating multi-band HF equipment that outputs 2 meters and 440 MHz to a single antenna connector. This dual-band loop allows you to jump from 2 meters to 70 cm without any coax switching.

The popular single-band 2-meter horizontal loop may incorporate a capacitive end-element termination, compensating for its relatively small size, for compact, sturdy mobile operation. The feedpoint may include a gamma match and/or series capacitance, usually encased within a protective cover. The loop antenna offers high-Q performance with an extremely sharp SWR drop at the bottom of the 2-meter band. Rain or icing may dramatically de-tune these small loops, so each manufacturer has developed its own unique capacitive end-loading scheme—some using a gap in the loop, and others terminating to a solid insulator at the loop ends.

Of great importance to the construction of these loop antennas, including home-brew, is zero vibration of loop elements where they join capacitive matching assemblies. During the 20 years of testing very-high-frequency loops, noted VHF/UHF SSB DXer Frank, AA2DR, concluded that only the most rigid loop element structures will withstand typical mobile operation. And when ice storms hit Long Island, Frank reports the immediate demise of both mobile loops as well as mobile loop performance over the air.

There are several manufacturers of horizontal loops, and during the many tests in which we participate at the seashore in our mobile communications van, loop reception and loop trans-

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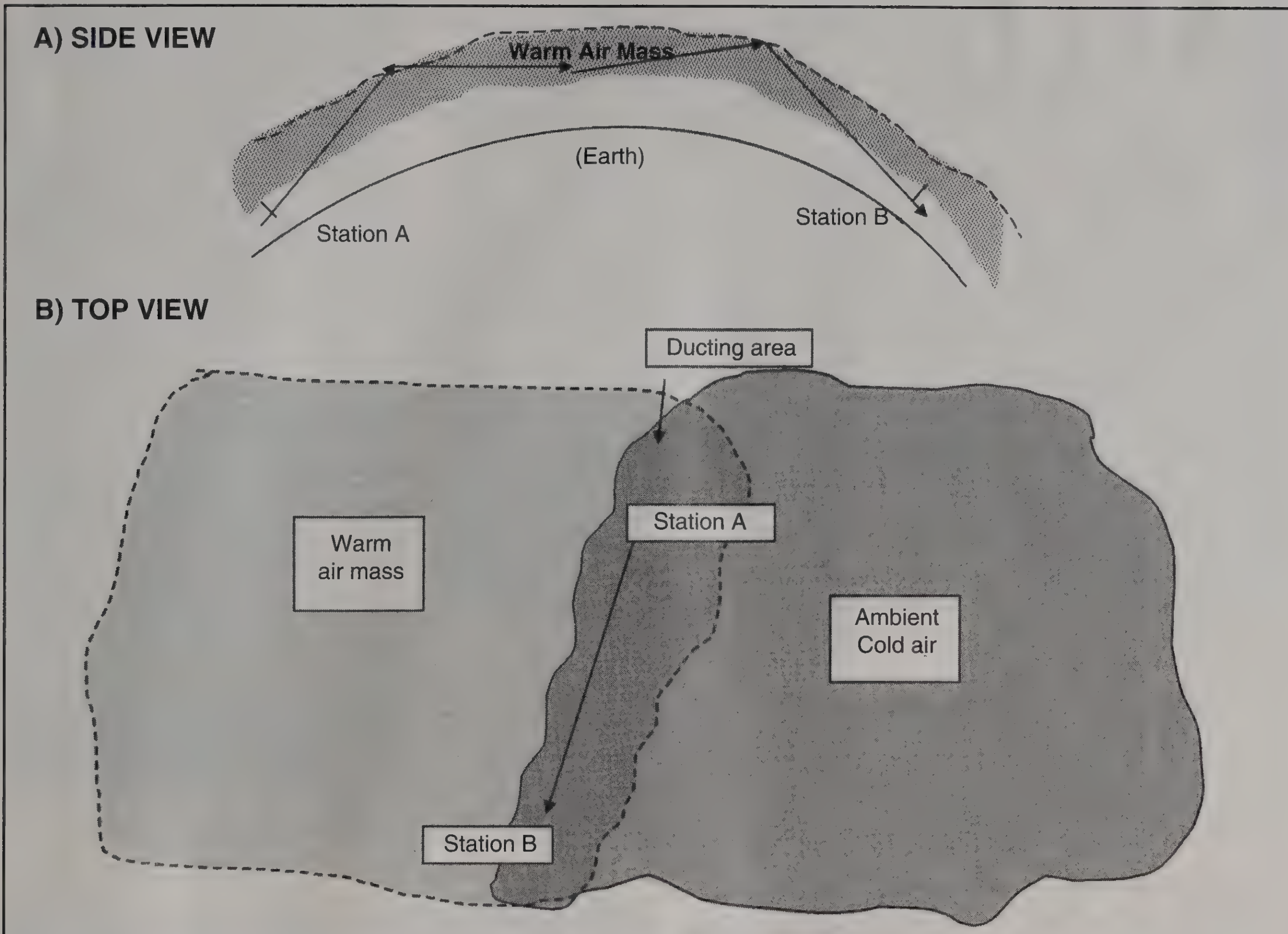


Figure 1. Tropospheric ducting. Note that tropo ducting can occur at different times on all of the VHF bands.

mit capabilities were nearly identical among manufacturers' products. Larger size loops, such as the Big Wheel design from W1FVY and W1IJD, have an edge in performance, mainly due to their larger size of three one-wavelength elements, all connected in parallel, using stub feedpoint matching to raise the feedpoint to 50 ohms. Although the Big Wheel design may flap in the breeze at 60 miles an hour, the broad-band design does not de-tune, as long as the stub matching network remains absolutely solid.

We also tested signal reception and transmit enhancement by stacking loops (2 meter) 48 inches apart ($^5/_8$ wavelength) using a T-connector with a bottom on $^1/_4$ wavelength of RG-59 and the top loop with $^3/_4$ wavelength coaxial cable, following the explicit directions on how each coax cable connector should be facing. Misalignment of loop feedpoints is a common problem with stacking antennas, and you must follow the antenna manufacturer's instructions to the letter in order to achieve the desired gain of 3 dB. Typically in our mobile tests we never saw a huge difference in picking up the Hawaii beacon with a single loop versus a pair of stacked loops. However, on an antenna test range or in the attic of your condo, stacking loop antennas may have 2 dB gain merit.

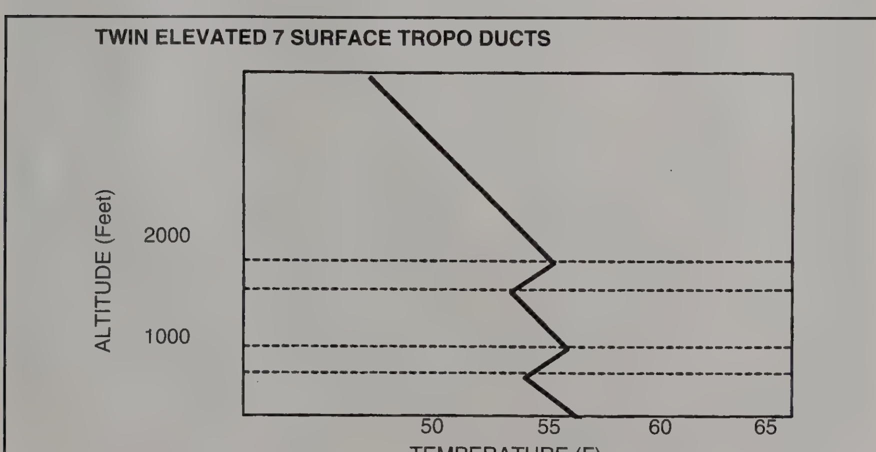
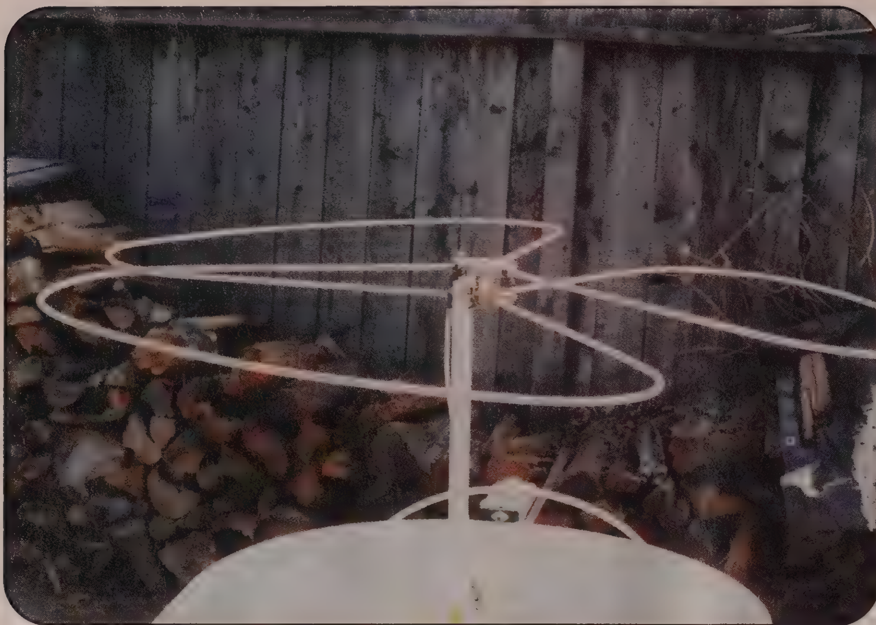


Figure 2. Evening double tropo enhancement due to heat rising from land.

The Weather

The largest contributor to an increase in signal strength is favorable weather conditions to create the long-haul tropospheric duct. Between California and



Classic "big wheel" 2-meter horizontal antenna.

Two-meter stacked loops with a single 6-meter loop on the left.

Hawaii, or Denver to Chicago, or Chicago to Texas, or Texas to Miami, the path depends on a stationary high-pressure system to create an inversion layer with a refractive index greater than the air below. Temperature inversions from stratified sinking air, within a high-pressure cell, that approach delta 10 degrees Fahrenheit increase will likely trigger the waveguide effect of the tropospheric duct. If this undisturbed inversion stratification remains intact for over 1000 miles, that may be how far your loop will talk and listen! Summertime high-pressure cells develop all over our Northern Hemisphere, and if you carefully monitor "tropo" forecasts, your little loop will most likely work the circuit when band conditions build.

No loop will ever achieve the results of a horizontally polarized beam. However, beams on a mobile (in motion) are generally rare, but horizontal loops are common.

Close-up of the M² loop ready for the mounting bracket.

A dual-band KU4AB.com loop with solid-rod construction on WB6NOA's communications van, 144.2 and 432.1 MHz with one feedpoint!

Now that most manufacturers are including VHF/UHF multimode capabilities in their relatively small HF transceivers, the popularity of the compact loop for *portable* operation is increasing. Last year during an intense 2500-mile opening between the West Coast and Hawaii, my wife Suzy did more than sell seashells at the seashore; she worked 2-meter SSB into a loop for some unbelievable DX! I run loops on my dune-buggy for 2-meter and 70-cm "tropo" elevation surveys and the 2-meter/70-cm loops were my companions at Catalina Island '08 Field Day activities, easily working mainland hams on SSB and CW. Also, five years ago, we worked Paul, KH6HME, using a West Coast single loop antenna over the long ocean path to Hilo, Hawaii.

When a tropospheric duct opens up communications between two distant stations, signal strengths at modest power levels may peak well above S-9. This is more than enough latitude to open communication possibilities between a distant station using a beam and the other end of the circuit with "just" a loop!

Resources

<www.KU4AB.com>: dualband loop
PAR Electronics (561-586-8278): Omniangle
<KB6KQ.com> (new owner): loops
M^2 (www.m2inc.com): HO loop
Olde Antenna Lab (303-841-1735): Big Wheels
<HamUniverse.com>: loops
<ErikBurrows.com>: loops
K1RST: loops
<dxinfocentre.com>: Hepburn Tropo Maps

Observing the Double-Hop Sporadic-E Phenomenon on 6 Meters

During the sunspot cycle low, North American 6-meter operators find it difficult to work many countries. WB2AMU suggests a possible solution to this dilemma.

By Ken Neubeck,* WB2AMU

In Europe and other parts of the world, countries are located close enough to one another such that they can be worked on 6 meters via single-hop sporadic-*E* (E_s). This is also true for 6-meter stations located in the southern U.S., where they are within single-hop range of many Caribbean and Central American countries. However, for many 6-meter stations that are located in the northern portion of the U.S. and much of Canada, there are not a heck of lot of DXCC countries that can be worked via single-hop sporadic-*E* skip. This would normally be a bleak situation for these operators in their pursuit of DX on 6 meters when *F2* is not a factor. On the other hand, the occasional presence of simultaneous multiple sporadic-*E* formations can help in working long-range DX on 6 meters.

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Observations

One thing that I have observed over the years with regard to double-hop sporadic-*E* events (see figure 1) is the fact that they are very rare during the months not in the summer sporadic-*E* season (May through August for the Northern Hemisphere). Indeed, even though there is a minor winter window for sporadic-*E* activity, and there have been rare events over the years during the equinox period, I can only recall a very small number of double-hop sporadic-*E* events that I have observed during the non-summer months over the past 15 years. I recall a special occasion when I observed a double-hop event one evening in the middle of March 1996, when stations in Arizona were being heard on Long Island, along with single-hop skip stations from the Midwest. Otherwise, I have not recorded any multiple-hop sporadic-*E* events during any of the winter months (October through February) in over 15 years of personal observations.

The significant reduction of double-hop sporadic-*E* events during the non-summer months is a general, not statistically based indicator of the overall reduction of sporadic-*E* activity when comparing the two time periods. If we use the observed summer season data that I have collected on 6 meters over the years (see Table 1) and compare it with no days of E_s during the other months, this could almost be summed up as roughly a ratio of 100 to 1 for my particular location. While this clearly is not meant to be a scientifically accurate calculation, it gives a

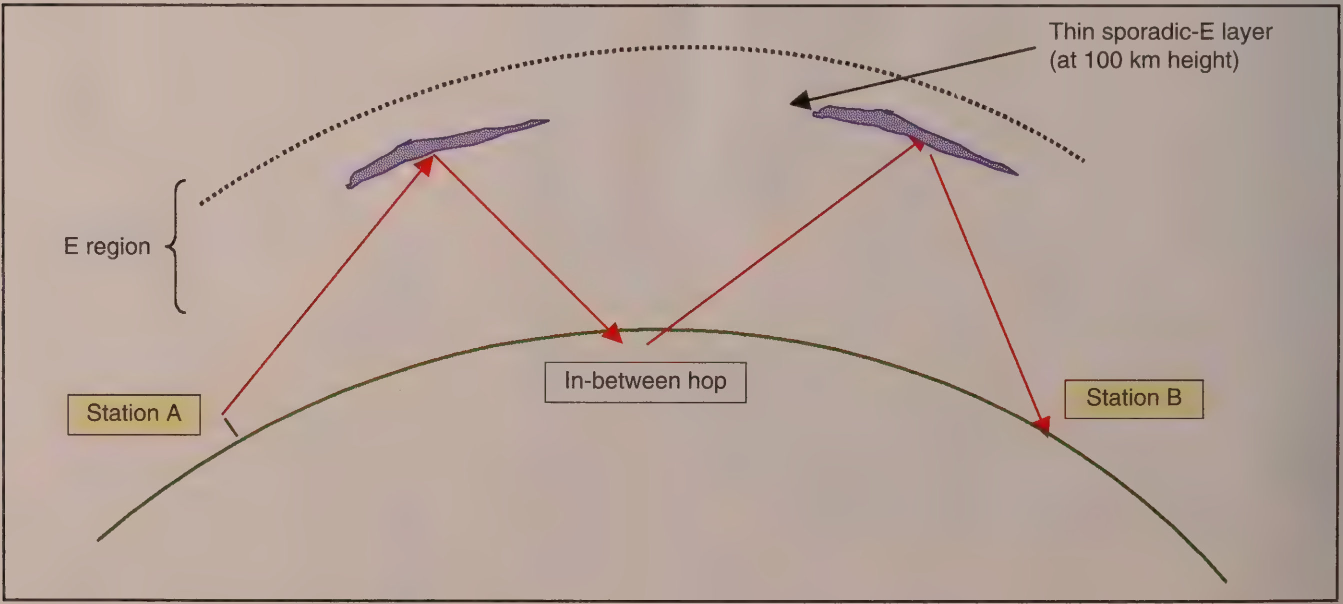

Figure 1. Double-hop sporadic-E pictorial description.

rough order of magnitude as to how intense the summertime sporadic-*E* season is compared with the winter season.

Perhaps the thing that is most important to note is that observations of double-hop sporadic-*E* events is location dependent, as some locations such as the New England area can experience many more such openings into Europe during the summer months. My location on Long Island is not in that "magic spot" for observing Europe as is, say, K1TOL in Maine, who is geographically favored as well as geometrically favored in terms of the distance for the two hops.

The earliest that I have ever observed double-hop sporadic-*E* during any year was on May 9th, and the latest that I have observed it is August 17th, roughly a 90- to 100-day window of opportunity for my location. It is most likely that this window of opportunity is somewhat larger for areas such as New England into Europe, and the southeast U.S. into the Caribbean. It could loosely be argued that the peak months for double-hop sporadic-*E* are June and July. This would not be based on just my observations, but also on the observations of stations in New England. It is also noted that in most cases, the double-hop sporadic-*E* activity begins almost as soon as the sporadic-*E* season begins in May and lasts into August.

Also under consideration in this analysis is the fact that there are situations in which the observing station is hearing signals from two opposite directions. This scenario, while not technically called a double-hop sporadic-*E* event for the observing station, is truly a dual-formation sporadic-*E* event. These events are also reflected in Table 1 as recorded in the notes that I have collected over the years. I have not recorded any such events in all of my years on 6 meters during the wintertime sporadic-*E* season. They are a challenge to record, as they are not always obvious, particularly if the beam is pointed in the direction of one of the sporadic-*E* formations, reducing the strength of the signals from the direction where the other formation is. It is important to note that this case is distinct and not to be confused with strong sporadic-*E* events that create backscatter conditions in the opposite direction (the backscatter signals typically are not as strong).

As discussed in previous *CQ VHF* articles, there are variations in individual sporadic-*E* openings in terms of signal strength (uniformity of the formation), density (the highest frequency reflected), and duration (time). Thus, one can imagine the extreme number of variations involved when dealing with two sporadic-*E* formations occurring at once! Sometimes the stations at the end points of the two hops can hear one another for only a few minutes, or sometimes for several hours. Sometimes stations in between the two stations on either end of the QSO are very strong, and this can lead to difficulty in the double-hop stations being able to hear one another underneath much stronger signals.

In some rare cases, the in-between hops may be in an area where there are few stations, making it easier for the stations on the end of the two hops to be able to work one another with less interference. I found this to be the case during a 6-meter opening from my QTH on Long Island into the Arizona and southern California area on the evening of June 4, 2008. I was able to work a decent number of western stations over a three-hour period without hearing many in-between stations. I heard a few W4s and W9 stations in

Kentucky and Indiana, but they were not excessively strong and did not cause a problem for me (see Table 2). It can sometimes be a roll of the dice as to how easy it is to work stations via double-hop, because where the in-between hop falls can dictate the amount of interference that will have to be dealt with!

Another interesting thing is figuring out which of the two sporadic-*E* formations is stronger. In the past, when I heard strong signals on a single-hop opening I sometimes heard some double-hop signals come in later with weaker signal strength. This suggests that the initial formation was probably the "stronger" of the two. Stronger is a relative term when discussing a formation, and a better term may be the *uniformity* of the formation where there is minimal fading. I suspect that the opening that I listed in Table 2 had a stronger second formation (the sporadic-*E* formation that was closer to the western stations), because I did not hear very strong signals with the first formation (the one closest to me).

Table 1 also shows that there is variability in the number of double-hop events on a year to year basis for any particular location. For example, 2004 was a poor year, while 2006 was an exceptional year. I suspect that there are multiple formations that can appear at the same time but may not be in a favorable position where they can be linked. When this situation occurs, it most likely is a function of the density and the distance between the two formations as shown in figure 2. The density of one formation

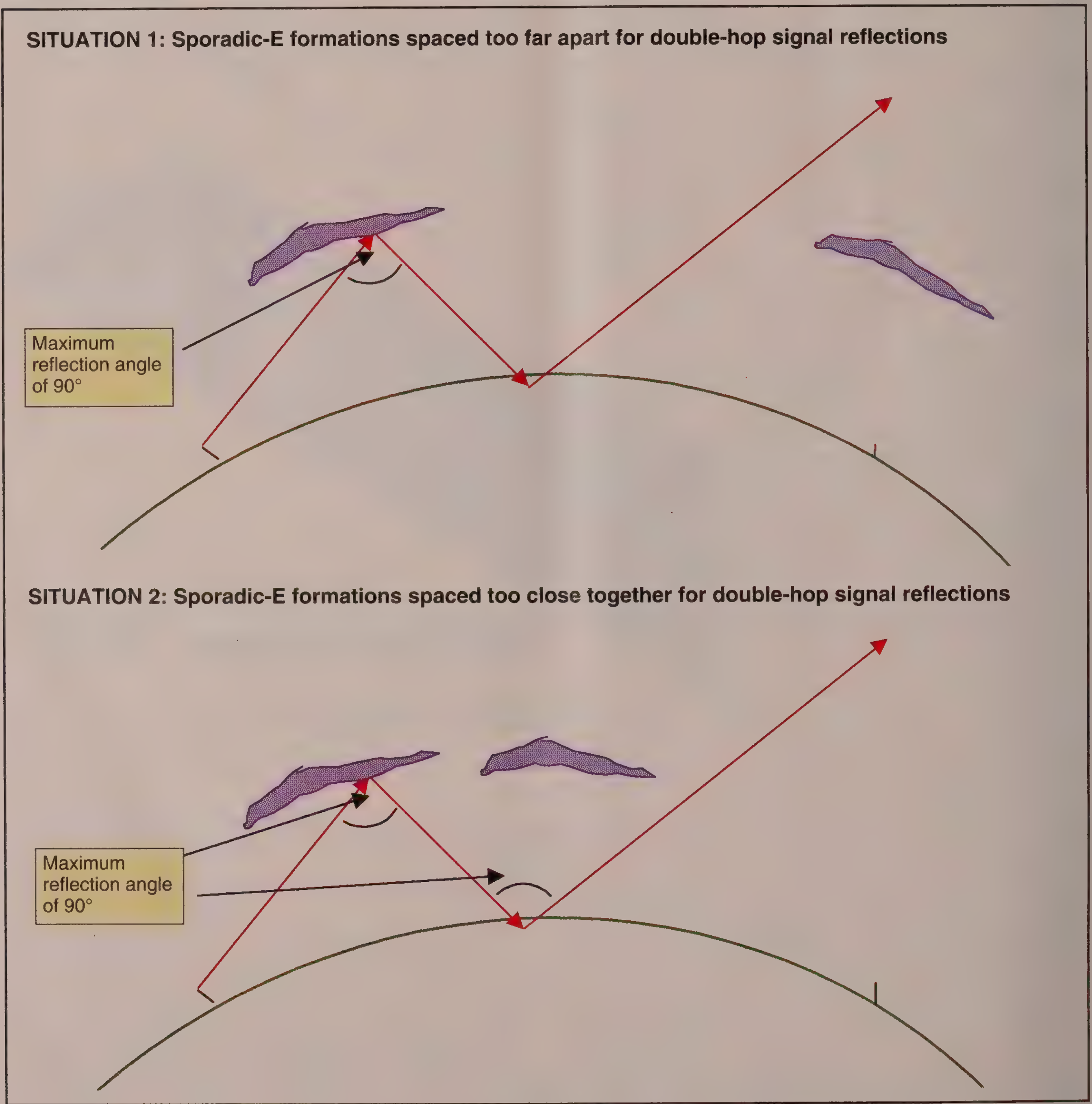

Figure 2. Near-misses for double-hop sporadic-E events.

	May		June		July		August		%	Earliest & Latest
Year	E_S	$2{\times}E_S$	E_S	$2{\times}E_S$	E_S	$2{\times}E_S$	E_S	$2{\times}E_S$	$E_S/2{\times}E_S$	Day for $2{\times}E_S$ Event
2000	13	2	19	5	23	7	9	1	23.4%	May 26, August 4
2001	18	1	21	5	21	11	12	2	26.4%	May 31, August 17
2002	7	0	20	1	11	0	9	1	4.3%	June 11, August 4
2003	16	1	14	4	26	6	8	0	17,2%	May 24, July 29
2004	12	0	12	1	14	2	8	1	8.7 %	June 20, August 4
2005	14	3	10	1	14	2	11	1	14.3 %	May 20, August 9
2006	16	6	17	3	20	10	3	1	35.7%	May 21, August 3
2007	5	1	16	8	20	7	2	0	23.2%	May 9, July 29
Total	**101**	**14**	**129**	**28**	**149**	**45**	**62**	**6**	**21.1%**	**(93 days /441 days)**

Note: The total for double-hop sporadic-E events also includes events where I heard skip in two opposite directions.

Table 1. Number of days of double-hop sporadic-E events observed at WB2AMU (FN30).

may be poor and it may be too close to (or too far from) the other formation, where it could not possibly link 6-meter signals. This certainly could account for some of the variability in the total number of double-hop sporadic-*E* events that are recorded during any summer season.

Generally, it is recommended that directional antennas be used to be able to work double-hop sporadic-*E*. However, that does not mean that lesser antennas will not work. On May 22, 2008 I was at my work QTH located in the middle of Long Island. I was listening with just my mag-mount vertical antenna on my car when I heard a moderately strong CW signal on 50.098 MHz. It turned out to be CU2JT from the Azores! I started my car and pumped the power to 70 watts on my FT-100, and I was able to work him after he finished a QSO with another Long Island station. This was a better-than-average type of double-hop situation. However, directional antennas are generally better because of fading conditions that can occur during two-hop situations.

Over the years, there have been days when sporadic-*E* formations seemed to be everywhere. When such events occur during a major contest such as the ARRL VHF QSO Party, the CQ WW VHF Contest, or ARRL Field Day, it becomes easier to track the number of formations present. One such event that I observed was Field Day 1994, when major openings were occurring everywhere on 6 meters during the first two hours of the event. From my location on Long Island, not only were we hearing stations from the Midwest, but eventually also weak signals from Europe in the other direction! I found out later that stations in Florida (such as Damon Morrison, KJ4E) had a prolonged opening into much of Europe (he worked 120 stations in 21 countries!). I also collected other reports from Field Day stations around the country. The West Coast was working the East Coast, and stations in southern California were working stations in the Pacific Northwest! During the first two hours of that particular Field Day, I estimated that there were at least six, possibly even seven, sporadic-*E* formations present at the same time. I would guess that during each summer there are days when four or five sporadic-*E* formations occur at roughly the same time but are not always fully captured unless a contest or similar event is going on.

A problem that is specific to coastal area such as the East Coast and West Coast of the U.S. is the sporadic-*E* paths that land in water, including double-hops. For me, one eastern path falls around the area of the Azores Island. Usually I can work into that area or coastal Portugal about once or twice each year during the summer. However, I can only imagine the number of those paths that land directly on water outside of those areas, where there are no islands or 6-meter stations. Sometimes these paths are discovered when there are maritime-mobile stations around, such as when Clint, W1LP, used to go up and down the East Coast, as well as others who went into the mid-Atlantic. During the summer of 2008, Yuri, UT1MM/mm, is one ham who is going through water grids in the Atlantic Ocean and being worked on 6 meters, often on double-hop sporadic-*E*.

Time (UTC)	Callsign	Grid
0034	N7KA	DM65
0053	W7RV	DM35
0135	K7JA	DM03
0127	W6DCC	DM13
0133	W6OAR	DM14
0136	W6PJ	DM43
0150	K7BHM	DM43
0155	N6RV	DM03
0207	WA7NB	DM42
0221	K7NN	DM42
0255	AA6DD	DM13

Table 2. Stations worked by WB2AMU (FN30) during double-hop sporadic-E opening on June 5, 2008.

Summary

What conclusion does all of this information eventually lead to? First of all, by virtue of multiple-hop sporadic-*E* formations being present, the summer season easily dwarfs the winter season. The difference is not merely in the larger number of occurrences, but actually could be expressed on the order of exponential terms! There is an average of at least ten days of double-hop sporadic-*E* activity during the summer season for most stations located in the middle-temperate zone, while double-hop sporadic-*E* during the winter is a pretty rare event.

It also points to the fact that there is a significant amount of ion activity in the *E*-region during the summer, as multiple formations can occur. This information can imply the importance of solar radiation effects on the oxygen ions in the *E*-region during the summer, whereas these effects are greatly minimized outside of the summer months.

Six-meter operators thus should keep in mind the importance of daily monitoring from May 1st through mid-August in order to capitalize on multiple sporadic-*E* events when they occur. These events help in the pursuit of DX, until the next *F2* season arrives in a few years. ■

QUARTERLY CALENDAR OF EVENTS

Current Contests

August: There are two important contests this month. The **ARRL UHF and Above Contest** is scheduled for August 2–3. The first weekend of the **ARRL 10 GHz** and above cumulative contest is scheduled for August 16–17.

September: The **ARRL September VHF QSO Party** is September 13–15. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 20–21. The **ARRL 2304 MHz and Above EME Contest** is September 20–21. The following dates for the **Fall Sprints** are based on last year's dates. Please check with the sponsor for the exact dates. The **144 MHz Fall Sprint** is September 15, 7 PM to 11 PM local time. The **222 MHz Fall Sprint** is September 23, 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 1, 7 PM to 11 PM local time. The **Microwave (902 MHz and above) Fall Sprint** is October 11, 6 AM to 12 PM local time. The **ARRL 50 MHz to 1296 MHz EME Contest** is October 18–19. The **50 MHz Fall Sprint** is October 18, 2300 UTC to October 19, 0300 UTC.

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 15–16.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or: <http://www.arrl.org>. For Fall Sprint contest rules, see the Southeast VHF Society URL: <http://www.svhfs.org>.

Current Conferences and Conventions

September: The 2008 **TAPR/ARRL Digital Communications Conference** will be held September 26–28 in Chicago, Illinois, at the Holiday Inn Hotel Elk Grove Village, Illinois. For more information, see: <http://www.tapr.org/dcc.html>.

October: The 2008 **Microwave Update** conferencewill be held October 17–18, in Bloomington, Minnesota at the Holiday Inn Bloomington I-35. For further information, please check the Microwave Update website: <http://www.microwaveupdate.org>.

The 2008 AMSAT-NA Space Symposium and Annual Meeting is to be held October 23–26, in Atlanta, Georgia at the Doubletree Buckhead Hotel. For more information, please see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat-new/symposium/2008/index.php>.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

Aug. 2	New Moon
Aug. 3	Very Good EME conditions
Aug. 8	First Quarter Moon
Aug. 10	Moon Apogee; Very poor EME conditions
Aug. 12	*Perseids* Meteor Shower Peak
Aug. 16	Full Moon
Aug. 17	Moderate EME conditions
Aug. 23	Last Quarter Moon
Aug. 24	Moderate EME conditions
Aug. 26	Moon Perigee
Aug. 31	New Moon; Good EME conditions
Sept. 7	Moon Apogee and First Quarter Moon; Poor EME conditions
Sept. 14	Moderate EME conditions
Sept. 15	Full Moon
Sept. 20	Moon Perigee
Sept. 21	Moderate EME conditions
Sept. 22	Last Quarter Moon and Fall Equinox
Sept. 28	Good EME conditions
Sept. 29	New Moon
Oct. 5	Moon Apogee. Very poor EME conditions
Oct. 7	First Quarter Moon
Oct. 12	Good EME conditions
Oct. 14	Full Moon
Oct. 17	Moon Perigee
Oct. 19	Poor EME conditions.
Oct. 20	*Orionids* Meteor Shower Peak
Oct. 21	Last Quarter Moon
Oct. 26	Moderate EME conditions
Oct. 28	New Moon
Nov. 2	Moon Apogee. Very poor EME conditions
Nov. 6	First Quarter Moon
Nov. 9	Good EME conditions
Nov. 13	Full Moon
Nov. 14	Moon Perigee
Nov. 16	Moderate EME conditions
Nov. 17	*Leonids* Meteor Shower Peak
Nov. 19	Last Quarter Moon
Nov. 23	Moderate EME conditions
Nov. 27	New Moon
Nov. 29	Moon Apogee
Nov. 30	Very poor EME conditions

—EME conditions courtesy W5LUU

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, e-mail, etc., contact the person listed with the announcement. The following organization or conference organizer has announced a call for papers for its forthcoming conference:

Microwave Update: A call for papers has been issue for the 2008 Microwave Update conference, to be held in Bloomington, Minnesota. The deadline for submission is August 31. If you are interested in submitting a paper for publication in the *Proceedings,* then, please contact Jon Platt, WØZQ, at <w0zq@aol.com> for additional information.

AMSAT-NA 2008 Space Symposium: Technical papers are solicited for the 2007 AMSAT Space Symposium and Annual Meeting to be held October 23–26 in Atlanta, Georgia. Proposals for papers, symposium presentations, and poster presentations are invited on any topic of interest to the amateur satellite program. Papers on the following topics are solicited: Students & Education, ARISS, AO-51, P3E, Eagle, and other satellite-related topics. Camera-ready copy on paper or in electronic form is due by September 1 for inclusion in the printed symposium *Proceedings.* Papers received after this date will not be included in the printed proceedings. Abstracts and papers should be sent to: Daniel Schultz N8FGV by e-mail at <n8fgv@ amsat.org>.

Meteor Showers

August: Beginning around July 17 and lasting until approximately August 24, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 1130–1400 UTC on August 12. A possible tertiary peak may occur around 1640 UTC. The *κ-Cygnids* meteor shower is expected to peak on August 17. The visually-impossible *γ-Leonids* is expected to peak August 25, around 0400 UTC. The *α-Aurigids* is expected to peak on August 31.

October: The *Draconids* is predicted to peak somewhere around 1030 UTC on October 8. The predicted ZHR may reach storm levels. The *Orionids* is predicted to peak on October 21.

November: The *Leonids* is predicted to peak around 0250 UTC on November 17 . As with last year's shower, this year's peak may go largely unnoticed.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's VHF Propagation column which begins on page 63. Also visit the International Meteor Organization's website: <http://www.imo.net/calendar/2008>.

The Basement Laboratory Group: A Pioneering VHF Club

Part 1—Carl Scheideler, W2AZL

Following his successful year-long series on KH6UK, Mark Morrison continues his look back at other pioneers of weak-signal VHF communications.

By Mark Morrison,* WA2VVA

The hills of northern New Jersey, bordered to the west by the Delaware River and to the east by Newark Bay, have always been rich in natural resources. History tells us that the Lene Lenape Indians first hunted and fished in these hills hundreds of year ago. In the 1800s, the rivers that cross this region supported a thriving canal system, bringing coal from Pennsylvania to the industrial centers in Paterson and Newark. Later came the railroads, transporting huge quantities of mineral ore and fueling an industrial revolution here. Hematite, an ore used in the production of iron and steel, spurred the building of factories and railroads. Copper and zinc, which were used to make wire and batteries, helped the telegraph and telephone industries grow here. Galena, an important mineral to "crystal radios" was processed into lead for batteries and other uses. Mica, which even today can be found in large sheets, became a critical component in vacuum tubes due to its electrical and thermal-insulating properties.

Industry flourished in these hills, with names such as Edison, Marconi, RCA, and Western Electric all setting up shop. For all its natural resources, however, the greatest was that of the working class people who lived here in the first half of the 20th century. These were the people whose hard work and determination shaped the world we live in today.

With a huge technical pool to draw from, northern New Jersey played a central role in the development of amateur as well as

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Photo A. Left to right: Mike Markus; unknown; John Manna, John Linse, K2HAC; Carl Scheideler, W2AZL; unknown; unknown; Benny Cembrola, WA2MTT; unknown; unknown; unknown; and Bob Henne, W2FCC.

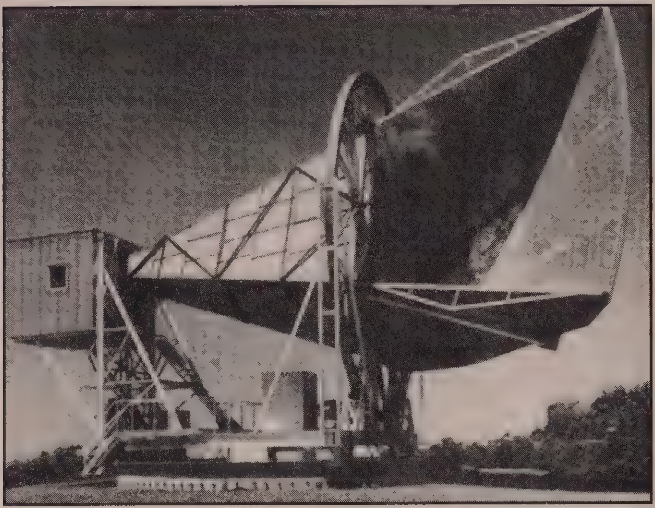
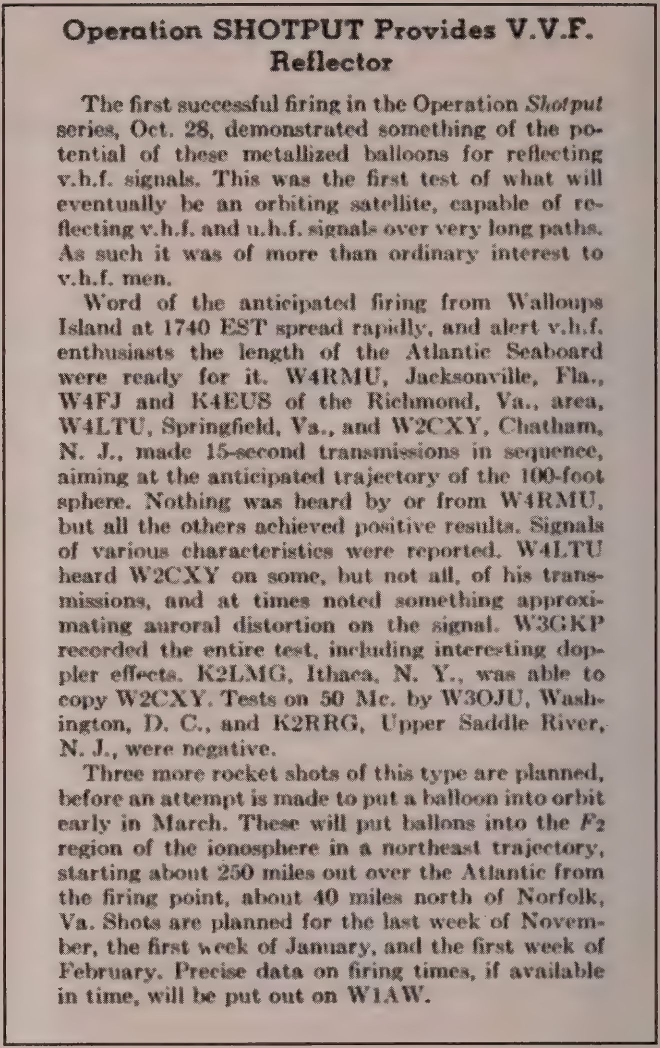


Photo B. The Holmdel horn antenna circa 1960 that was used for Project Echo. This antenna is now listed as a National Historic Landmark. (Bell Labs photo)



Operation SHOTPUT Provides V.V.F. Reflector

The first successful firing in the Operation *Shotput* series, Oct. 28, demonstrated something of the potential of these metallized balloons for reflecting v.h.f. signals. This was the first test of what will eventually be an orbiting satellite, capable of reflecting v.h.f. and u.h.f. signals over very long paths. As such it was of more than ordinary interest to v.h.f. men.

Word of the anticipated firing from Walloups Island at 1740 EST spread rapidly, and alert v.h.f. enthusiasts the length of the Atlantic Seaboard were ready for it. W4RMU, Jacksonville, Fla., W4FJ and K4EUS of the Richmond, Va., area, W4LTU, Springfield, Va., and W2CXY, Chatham, N. J., made 15-second transmissions in sequence, aiming at the anticipated trajectory of the 100-foot sphere. Nothing was heard by or from W4RMU, but all the others achieved positive results. Signals of various characteristics were reported. W4LTU heard W2CXY on some, but not all, of his transmissions, and at times noted something approximating auroral distortion on the signal. W3GKP recorded the entire test, including interesting doppler effects. K2LMG, Ithaca, N. Y., was able to copy W2CXY. Tests on 50 Mc. by W3OJU, Washington, D. C., and K2RRG, Upper Saddle River, N. J., were negative.

Three more rocket shots of this type are planned, before an attempt is made to put a balloon into orbit early in March. These will put ballons into the F_2 region of the ionosphere in a northeast trajectory, starting about 250 miles out over the Atlantic from the firing point, about 40 miles north of Norfolk, Va. Shots are planned for the last week of November, the first week of January, and the first week of February. Precise data on firing times, if available in time, will be put out on W1AW.

Figure 1. Article on Operation Shotput from November 1959 QST. *(Images in this article from* QST *courtesy of* QST *and the ARRL)*

professional communications in the years following WW II. Logbooks from the late 1940s show a spattering of VHF calls, mostly within 50 miles of each other. In those days you had to be something of a pioneer to be on VHF, as commercial equipment was not yet widely available. Before the war a typical VHF station might have been home built, but in the years following WW II, surplus equipment such as the venerable SCR-522 VHF transceiver made it possible for practically anyone with a license to get on the air.

Although commercial VHF equipment would eventually become available to hams from northern New Jersey companies such as Clegg Labs, Whippany Labs, and to a lesser extent Federal Telephone & Radio, it was helpful to know someone who happened to work for one of these companies. This was likely to happen if you belonged to one of the local radio clubs.

The Basement Lab Group

The Tri County Radio Association, one of the oldest ham clubs still in existence, became a local gathering place for numerous hams, including many notable VHF men. A small group of Tri County members with an interest in VHF radio started an informal group known as the Basement Laboratory Group, largely made up of employees of the Bell Telephone Laboratories, but open to anyone with an interest in VHF radio. Some members of this group would later play important roles in VHF radio, including many significant firsts. In this series of articles I hope to acquaint you with the members of this informal VHF group, and the roles they played in the history of amateur VHF communications.

Photo A, taken sometime in the early 1960s, shows some of the members of the Basement Lab Group . Included are some members of the Tri Country Radio Association as well as the local MARS VHF networks, both Air Force as well as Army. The location is thought to be Neptune, New Jersey. Note the classic halo VHF antenna on the bumper of the Plymouth Valiant.

The Basement Laboratory Group (BLG) was headed by Carl Scheideler, W2AZL, a talented RF design engineer who worked for Bell Labs. Carl's work is believed to have involved the microwave repeaters that were spread across the hilltops of America in the days before satellite communications. In those days both telephone and broadband television programming were distributed via microwave relay towers spaced 30 to 50 miles apart and using specially designed horn antennas. The low-noise amplifiers and traveling-wave-tube amplifiers developed for use in these towers would later be used in the satellite ground stations that ultimately replaced them. An upscale version of the repeater horn antenna (photo B) was used to track the Echo satellite, a metalized balloon recognized as the first (passive) communications satellite, although experiments of this nature were conducted by BLG members as early as 1959 (see figure 1).

In later years, this antenna would be fitted with the lowest noise receiver of the era, the newly developed MASER. The extreme sensitivity of this type of receiver, coupled with the unique ability of this horn design to distinguish weak satellite signals (Telstar used only a 3-watt transmitter) from naturally occurring background noise, eventually led scientists to discover evidence of the primordial Big Bang, but that's another story. Suffice it to say that Western Electric, the manufacturing arm of parent

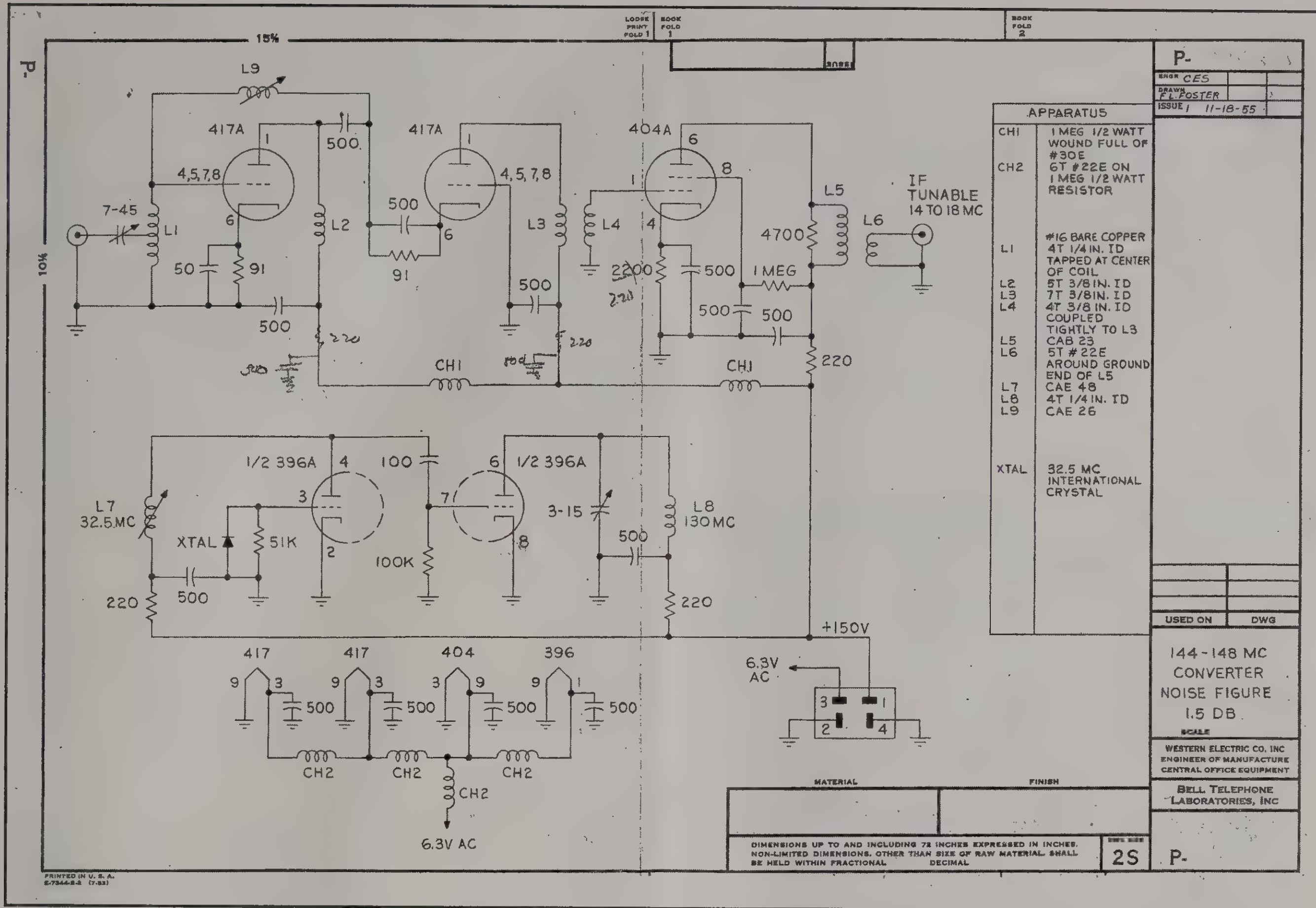


Figure 2. The original Bell Labs schematic dated 1955. Note Carl's initials "CES" in the upper right-hand corner.

company AT&T, spared no expense in doing things right and has long been recognized for high-quality components with exceptional performance. Even today, Western Electric audio amplifiers that were designed for use in public-address systems and movie theatres in the 1950s are highly prized by hi-fidelity collectors, with staggering prices paid for even simple examples. In the midst of this entire advanced engineering, it is no surprise that Carl would find one Western Electric component, the 417A planar triode, to be an ideal component for an amateur VHF converter.

The W2AZL Converter

At a time when VHF equipment could transmit farther than it could receive, largely due to the poor noise figure of commercially available equipment, having a low-noise converter that could be used with the best HF rigs of the day was a blessing to weak-signal operators. In the early 1950s Carl created his first low-noise 2-meter converter based upon the

Photo C. The W2AZL converter (right) with a matching power supply (left).

Western 417A. Figure 2 is an original Bell Labs schematic dated 1955 and shows Carl's initials "CES" in the upper right-hand corner.

Popularly referred to as the "W2AZL converter," Carl's design became a mainstay for many weak-signal operators well into the 1960s. Photo C is a picture of the converter (right) with a matching power supply (left). This equipment was used with the Collins 75A4 receiver in the background as part of the W2CXY meteor-scatter station throughout the 1950s.

Not only was this converter easy to build, but the open-chassis design facilitated simple modification as well. In the late 1950s versions of this converter were used on 6 meters as well as 108 MHz, the latter being the frequency assigned to United States satellites launched during the International Geophysical Year (IGY). By one account, this converter was even used in

Photo D. A seldom seen and unique variation of the W2AZL converter, one using the rare Western Electric 416B triode, a tube designed for operation up to 4 GHz.

A Two-Meter Converter with a Noise Figure Under 2 Db.

Optimum Performance in an Easily Duplicated Design

BY C. E. SCHEIDELER, W2AZL*

SOME ten years ago I became interested in investigating propagation at very high frequencies. In deciding which band to use, consideration was given to the availability of efficient high-power tubes for transmitters, the possibility of constructing a stable sensitive receiver, and the practicability of making a high-gain antenna of reasonable size, keeping in mind that it had to be erected in any average-sized back yard. The 144-Mc. band looked as if it would satisfy the requirements.

The first project was to build a stable low-noise converter to work into a communications receiver. A survey of low-noise amplifier circuits and tubes was made and it was decided to use the "Wallman Cascode" circuit in conjunction with 417A triodes. The 417A was designed for broad-band preamplifier service at 70 Mc. It has a transconductance of between 20,000 and 30,000 micromhos and is ideally suited to v.h.f. work.

When the first work was done with meteor scatter on 144 Mc. some years ago, all four participants, W2UK, W4HHK, W2NLY and W2AZL, used similar converters. This design, the work of W2AZL, has since been duplicated widely, from instructions and drawings similar to those presented here. Today the "W2AZL Converter" is practically standard equipment for v.h.f. men who want the best obtainable sensitivity on 144 Mc. Converters of this type were in use at both ends of the record-breaking 144-Mc. QSO across the Pacific, made in 1957 by KH6UK and W6NLZ. If a signal can be heard on your antenna, you can hear it with this converter.

Figure 3. Excerpt from December 1959 QST *showing the introduction of the W2AZL converter.*

2-METER STANDINGS

Figures are states, U. S. call areas, and mileage to most distant station worked.

W1REZ	29	8	1175
W1AZK	24	7	1205
W1RFU	22	7	1120
W1OAX	22	6	800
W1AJR	21	7	1130
W1HDQ	20	6	1020
W1MMN	20	6	900
W1IZY	19	6	875
W1AFO	17	6	920
W1ZJQ	17	6	860
W1CLH	17	5	450
K1ABR	16	6	810
W1BCN	16	5	650
W1KHL	16	5	570
W2CXY	37	8	1360
W2ORI	36	8	1250
W2NLY	35	8	1390
W2AZL	28	8	1050
K2GQI	27	8	1000
W2BLV	25	8	1020
K2IEJ	24	7	1060
W2DWJ	23	6	860
K2HOD	23	7	950
W2AMJ	22	6	960
W2SM	22	6	940
K2CEH	21	8	910
W2LWI	21	6	700
W2RXG	20	6	700
W2UTH	19	7	880
W2RGV	19	6	720
K2RLG	17	6	980
W3RUE	30	8	975
W3GKP	29	8	1020
W3KCA	28	8	1110
W3TDF	28	8	915
W3SGA	26	7	700
W3FPH	22	8	1000
W3NKM	20	7	730
W3LNA	20	7	720
W3LZD	20	7	650
W4HJQ	36	8	1150
W4HHK	35	9	1280
W4ZXI	34	8	950
W4AO	30	8	1120
W4MKJ	28	8	850
W4UMF	27	8	1110
W4VLA	26	8	1000
W4JCJ	23	6	725
W4EQM	22	8	900
W4WNH	22	8	800
W4OLK	20	6	720
K4EUS	19	6	710
W4CPZ	18	6	650
W4TLV	18	7	1000
W4RFR	18	7	820
W4MDA	17	6	650
K4YUX	16	8	830
W4CLY	15	5	720
W4RMU	10	5	860
W4LNG	10	5	800
W4KCQ	10	4	860
W4GIS	9	2	335
W5RCI	33	9	1215
W5DFU	25	9	1300
W5AJG	22	8	1280
W5JWL	21	7	1150
W5KTD	20	8	1250
W5LPG	19	6	1000
W5ML	15	5	700
W5PZ	14	6	1255
W5FSC	12	5	1390
W5HEZ	12	5	1250
W5CVW	11	5	1180
W5NDE	11	5	625
W5VY	10	3	1200

W5ONS	9	3	950
W5FEK	8	2	560
W6NLZ	12	4	2540
W6DNG	9	5	1040
W6AJF	6	3	800
W6ZL	5	3	1400
W6MMU	3	2	950
W7VMP	11	5	1280
W7JRG	6	3	1040
W7LHL	4	2	1050
W7JIP	4	2	900
W7JU	4	2	353
W8KAY	38	8	1020
W8WXV	35	8	1200
W8LOF	33	8	1060
W8PT	32	8	985
W8SVI	30	8	1080
W8SFG	30	8	1000
W8LPD	29	8	850
W8EHW	28	8	860
W8WRN	28	8	680
W8BAX	27	8	960
W8DX	26	8	720
W8ILC	25	8	800
W8JWV	25	8	940
W8NOH	21	8	975
W8LCY	21	7	610
W8BLN	21	7	610
W8BLN	18	7	780
W8GTK	18	7	550
W9KLR	39	9	1160
W9WOK	39	9	1150
W9GAB	32	9	1075
W9REM	31	8	850
W9AAG	30	8	1050
W9ZIH	30	8	830
W9EQC	26	8	820
W9ZHL	25	8	700
W9BPV	25	7	1030
W9PBP	23	8	820
K9AQP	23	7	780
W9LF	22	7	825
W9KPS	22	7	690
W9PMN	19	6	800
W9ALU	18	7	800
W9JIY	17	8	790
W9LEE	16	6	780
W9DDG	16	6	700
W9DSP	15	6	720
WØSMJ	27	8	1075
WØIHD	27	7	890
WØBFB	27	8	1060
WØGUD	25	7	1065
WØRUF	23	7	900
WØINI	21	6	830
WØUOP	21	7	900
WØTGC	21	7	875
WØZJB	18	7	1180
WØRYG	17	6	925
WØIFS	16	6	1100
WØJHS	13	5	700
WØIC	12	5	1240
VE3DIR	28	8	1100
VE3AIB	26	8	910
VE3BQN	19	7	790
VE3AQG	17	7	800
VE3DER	16	7	820
VE2AOK	13	5	550
VE3BPB	14	6	715
VE7FJ	2	1	365
KH6UK	1	2	2540

Figure 4. From October 1958 QST *"The World Above 50mc" column, this shows the W6NLZ to KH6UK contact.*

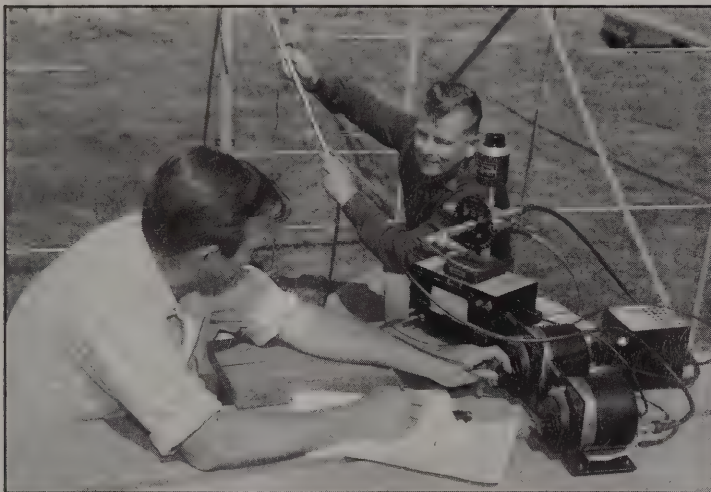


Photo E. Carl, W2AZL, assisting Walt Morrison, W2CXY, with his 2-meter array in 1956.

Photo F. This is another picture of Carl, W2AZL, at the controls. Note the slide rule in the foreground.

the Search for Extraterrestrial Intelligence (SETI)! Photo D is a rarely seen and unique variation of this converter, one using the rare Western Electric 416B triode, a tube designed for operation up to 4 GHz!

Carl distributed plans for this converter to interested parties throughout the 1950s, and even got help building and distributing them from his friend Walt Morrison, W2CXY. Eventually, Carl published a complete set of plans in the December 1959 issue of *QST* (see figure 3). Note the sidebar that gives some history on this type of converter.

Meteor Scatter

As hams started building these converters or buying similar products from Tecraft, Tapetone, and others, the range of amateur VHF communications expanded considerably. No longer limited to contacts just tens of miles away, reliable QSOs could now be made with stations hundreds of miles away. Aurora contacts accounted for many of the early VHF DX records, but when BLG associate Ralph "Tommy" Thomas, W2UK, and Paul Wilson, W4HHK, first demonstrated that meteor scatter was a viable alternative to aurora-caused propagation, it soon became possible to work stations a thousand miles away. The predictability of meteor showers also meant that operators could arrange schedules well in advance, as opposed to the unpredictable nature of aurora activity. Carl teamed up with Walt Morrison, W2CXY, as his local aurora and meteor-scatter partner, often working distant stations together and alerting one another to DX openings in progress. Both succeeded in making impressive strides in both distance worked and the number of stations contacted.

Moonbounce

In 1955, when BLG associate W2UK moved to Hawaii, the "basement engineers," as Tommy used to refer to them, would gather at Carl's QTH in Plainfield, New Jersey on most Thursday evenings. Although the purpose of these meetings was to keep in touch with Tommy, they also provided an opportunity to talk shop and simply enjoy one another's company. One topic of interest was moon-reflection work, or simply "moonbounce." When Tommy moved to Hawaii, he expressed interest in using this mode to talk to his "basement friends" back east. Having just opened the doors to meteor-scatter work, Tommy's interest in moonbounce was expected to have similar results. Carl and Walt spent many weekends fine-tuning their meteor-scatter arrays in hopes of also using them for moonbounce. Photo E shows Carl assisting Walt Morrison with

Photo G. Gathered at a luncheon honoring Dick Turrin, W2IMU, are members of the Eastern VHF/UHF Conference. Dick received a plaque for his work in UHF communications. Seated around the table (left to right) are Dick Turrin, W2IMU; Ed Chinnock, W2FZY; Roger Abson, WA2AHW; Pete Arnold, WA2DMT; Bill Legg, W2VE; Carl Scheideler, W2AZL; Vic Colaguori, W2OMS; and Bob Buus, WA2HVA. Tony Rustako, K2KII, is behind the camera. (From November 1975 QST*)*

the W2CXY 2-meter array in 1956. Photo F is another picture of Carl at the controls. Note the slide rule in the foreground.

Other Activities

Affectionately known as "Pappy," Carl was revered for his engineering knowledge and willingness to share it with others. Already well known for his low-noise converter designs, Carl's recommendations were soon recognized by the Heathkit Company, which approached Carl for help with some of its products. As a result of this, Heath rewarded Carl with some free equipment.

Carl and many of the Basement Engineers were also active in the Military Affiliate Relay System (MARS). It was through MARS that top-of-the-line HF receivers, such as the Hallicrafters R-274 and Hammarlund SP-600, could be obtained as military surplus. The stability of these receivers allowed their use as the IF stage for Carl's 2-meter converter. Just as important to the VHF operator were military VHF transceivers such as the SCR-522 and AN/ARC-1, which were also available through MARS. Carl and Walt belonged to the MARS Army VHF Net 10.

Carl also made an effort, perhaps more so than many others, to attend the various VHF conventions around the country, including the "First Moonbouncers Convention" in 1962. Also in attendance were BLG associates John Linse, K2HAC, and Bill Ashby, K2TKN, as well as extended members Tony Sheppard, VE3DIR, and Lawrence Lewis, W2ALR.

Photo G shows Carl (waving) at another meeting, that of the 1972 Eastern VHF/UHF Conference honoring Dick Turrin, W2IMU. Dick was another Bell Labs employee and was well known for his series of moonbounce notes commonly referred to as the "Crawford Hill Technical Notes." That's the same Crawford Hill where Karl Jansky, another Bell Labs employee, first discovered radio waves of extraterrestrial origin in 1931, thus opening the door to radio astronomy.

At the July 1973 Central States VHF Society conference Carl was elected vice president of the Central States VHF Society for its 1974 conference, which was held in Boulder, Colorado. While driving to the 1976 CSVHF Society conference in Houston, Texas, Carl talked about one day using phased vertical whips on the roof of the car to automatically tune in the strongest signal. Curiously, Carl shares a patent on "laminated conductor directional arrays," as shown in figure 5, from 1958.

1296-MHz Moonbounce

Although Carl and Walt had sizeable stations and often talked about moonbounce, it wasn't until Carl moved to Holmdel, New Jersey in the early 1960s that things got serious. In 1962 Carl and a few others assisted Walt in building the first 1296-MHz moonbounce station in New Jersey, and one of only three in the world at that time. In April 1962 W2CXY became only the third station in history to bounce a 1296-MHz signal off the moon to be heard by others. Sam Harris, W1FZJ, remarked that this was the first signal he'd heard off the moon since the first-ever moonbounce QSO with W6HB

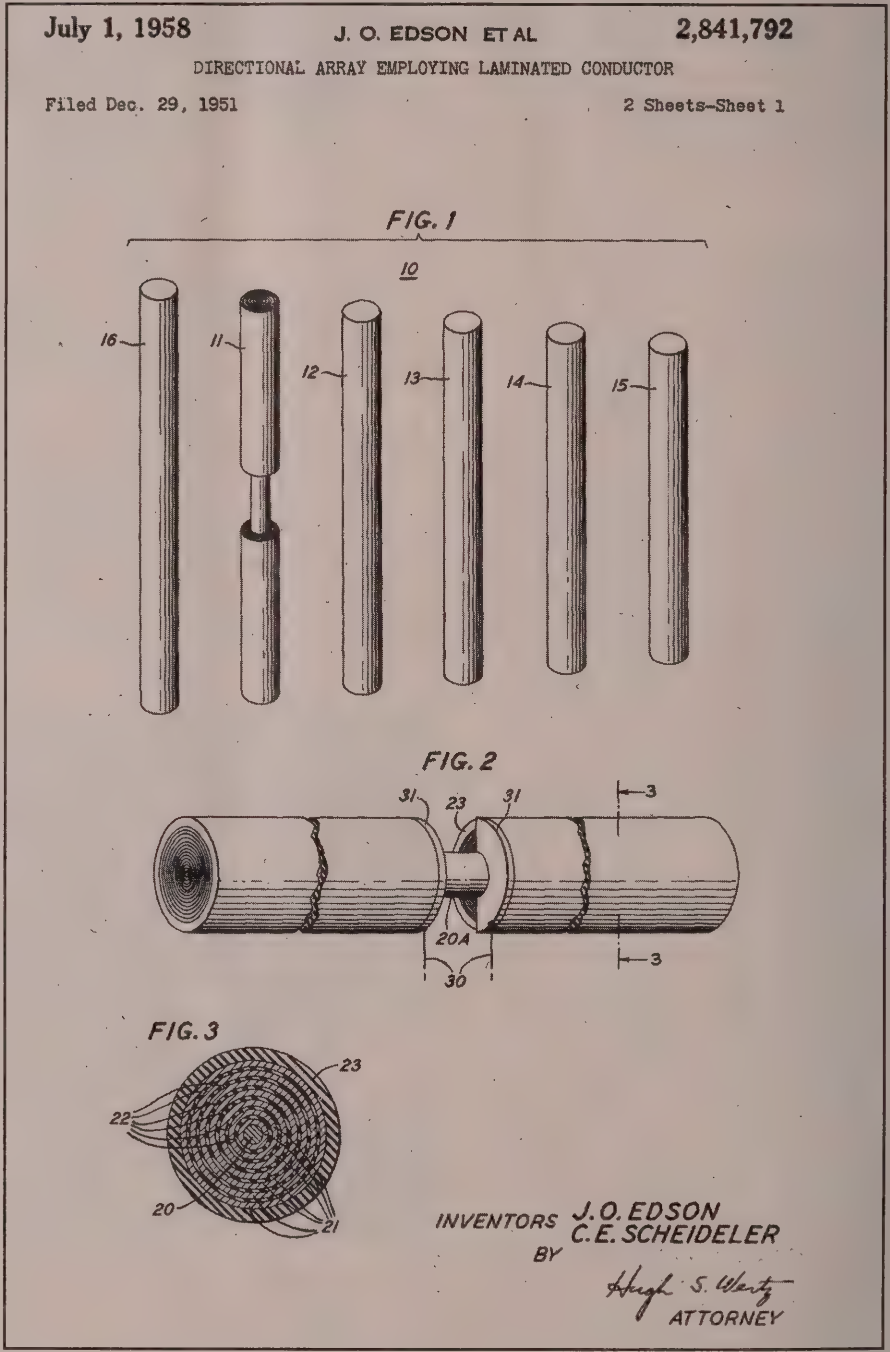


Figure 5. The 1958 patent drawing of the Directional Array Employing Laminated Conductor.

Photo H. Carl, W2AZL, with John Fox, WØLER, his partner in their historic first-ever 432-MHz meteor-scatter QSO. (From October 1972 QST*)*

in 1960. Carl's ubiquitous low-noise converter was part of that station, at least in one variation.

Even though Walt and Tommy had move up to 1296 MHz, Carl never really left 2 meters, but did give 432 MHz a try. In 1972 this decision paid off big as Carl and John Fox, WØLER, completed the first-ever meteor-scatter contact on 432 MHz. Photo H shows Carl with 432 meteor-scatter partner WØLER in 1972.

When Ralph "Tommy" Thomas returned from Hawaii in 1964, he settled in Colt's Neck, New Jersey, not far from Carl's QTH in Holmdel. Tommy and Carl apparently partnered with Herbert Power, WA2WOM, using a 2-meter array consisting of four log-periodic antennas, quite modest in comparison to some of the Long John arrays commonly used in the 1950s. This array led to Carl's 2-meter moonbounce success, first with the 150-foot dish of Stanford University (WA6LET) and later with Bob Sutherland, W6PO.

Summary

In later years Carl would attend lunch meetings with long-time BLG associates Ed O'Connor, K2TKN, Walt Morrison, W2CXY, and a few others. The highlight of these lunches was an occasional invitation to visit the Bell Labs Holmdel facility where Carl worked in order to see what Carl was working on. One such visit made by Walt was recorded on audio tape in the 1970s and reveals that Carl's work at that time involved cryogenics. More recently, the historic Holmdel facility was sold to a developer with plans to tear it all down. This would be a sad end to the building where so many of the world's greatest discoveries were made.

I remember Carl as a good friend, not just to my father, but to everyone who knew him. He was a true gentleman, with a friendly voice and a great sense of humor. Perhaps the most amazing thing about Carl was how modest he was. When others showed interest in setting new records, Carl was there to help, always putting his friends' goals before his own. His classic 417A converter may be remembered for getting so many amateur radio operators on 2 meters. However, his work as an avid VHF person and friend to so many hams will be his lasting legacy.

BIG BLUE Projects: One Student's Perspective

The spring issue of *CQ VHF* focused on the BIG BLUE flexible-wing project. Chandler explains what his involvement has meant to him both as a student and in his profession.

By Garrett Chandler,* KY1GDC

It is astounding the effects that volunteering a little extra time to work on an extra-curricular school project can have on someone. What started as a class project turned into much more than that—both for the remainder of the semester in which I first got involved, as well as for the time that has passed since then. There is no doubt that the BIG BLUE project has had a lasting effect on me personally and professionally.

It all began when I was taking an elective electrical engineering course in microcomputer systems design at the University of Kentucky. At the time I was working on my Masters of Science degree in Biosystems Engineering. A project-based class, the nucleus of our activities was a project in its second year—BIG BLUE. Our task was to design and construct the control and communication systems to enable the high-altitude test scheduled for less than four months from the first day I learned of the project.

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It was daunting, to say the least, but the excitement of being involved in something as great as this project promised to be was too much to pass up.

Before long I was put in charge of leading the design of the airborne system architecture. Working closely with the software development team once the hardware had been completed, I was able to learn an immeasurable amount about software design and engineering in a team environment. Before it all was said and done, those volunteered hours turned into 12-hour blocks at a time. As a team we consumed many liters of Mountain Dew soda, and on more than one occasion the sun rose before we left the campus.

In brief, what emerged from the other end of our development cycle was a multiprocessor system with some good-enough checks and balances to ensure the highest chance of success. A mix of three processors served as the auto pilot to the aircraft, master system controller, and a system supervisor, respectively.

Members of the design team after presenting a design review to top-level engineers at ILC, Dover. (Photos courtesy of the author)

The three-processor, two VHF radio, redundantly powered system is packed into the fuselage for the trip to space.

Garrett Chandler, KY1GDC, brushes up on the TH-D7A manual before heading out into the field for the BIG BLUE launch.

Testing of and adjustments made to the BIG BLUE system late into the night the day before launch.

This electrical spine controlled high-pressure inflation valves, servos, a parachute deployment system, high-current control of the video transmitter, and a ballistic cutter. All very fun stuff! In addition, we chose to use something new to me for our communication systems—amateur radio.

I had never heard of this amateur radio stuff before. As I learned more and more, I realized that I was missing out on a ton of fun. To officialize and legalize my involvement I was in need of an amateur radio license. Some studying and a few multiple-choice questions later and the callsign KI4IHG was mine.

The aircraft design ended up with two communication radios—Kenwood TH-D7s, to be specific. Those built-in TNCs saved us quite a bit of weight. One of these was used for bi-directional communication with the ground station and the other was dedicated to beaconing the reports coming from a GPS receiver.

In addition to all the design, development, bench testing, and flight testing that went on in the lab and just outside the back door, the project afforded many more great experiences. Over spring break of that year, I gave my buddies who were headed to Panama City and South Padre a pat on the back and jumped into the vehicle with the BIG BLUE crew and headed to Kitty Hawk, North Carolina. Instead of lollygagging around on warm sandy beaches that year, about 15 of my newfound friends and I spent our break flight testing our systems on the cold and breezy dunes on which Orville and Wilbur Wright toiled away exactly 100 years prior.

That trip to Kitty Hawk was just a few weeks after a similarly momentous occasion. In order to get some constructive criticism on our design, a few of us traveled to Dover, Delaware, where we presented content from our CDR (critical design review) to engineers at ILC Dover. It was an honor and a privilege (and a little intimidating) to stand in front of the same engineers who had designed the airbags for the Mars landers which had seen use in the Spirit and Opportunity missions just weeks before. It was an incredible experience.

My first involvement in the project culminated in the high-altitude flight test in Colorado on May 1st that year. All of the student-designed systems worked flawlessly. It was the premature failure of the weather balloon from which we got a tow that put us off course and prematurely ended the experiment. In spite of that disappointment, much was still gained from the trip. For me, a highlight was being the operator-in-charge at the "roving" ground station. (Three ground stations were used for the experiment: the primary at the launch site, the mobile under the predicted peak altitude for the mission, and the roving station at the anticipated touchdown point and the place where the flight test was to occur.) The position at the helm was afforded to me because by that time I was a card-carrying amateur radio operator.

After my first dive into the BIG BLUE project I continued my involvement in subsequent years by serving as a student advisor to the project and later as an external reviewer during

Ground tests of the electronics, radios, and wing system on the dunes of Kitty Hawk, North Carolina. The ground crew is visible in the lower left of the photo.

Next stop, the edge of space. BIG BLUE II at T+4 seconds (wings folded inside the fuselage).

the design review cycles. However, those follow-on experiences were minuscule in comparison to the path my initial involvement launched me on. For starters, it sold me on the fact that I really needed to add a Masters degree in Electrical Engineering to my repertoire. And beyond that, it paved the way for an even larger project—KySat.

It was my involvement and leadership within the BIG BLUE program that put me in the running and eventually scored me the seat as project leader and system architect for a statewide student program to design, build, launch, and operate a satellite. As of now, KySat1 is in the final test stages before being put in the launch queue later this year. It will enable students across the state of Kentucky and the world to "play" with a spacecraft with the goal of instilling within them a sense of excitement about science and engineering. Communication and command of the craft will be open to amateur radio operators using VHF HTs signaling the system with DTMF tones. Data is exchanged with the satellite via typical satellite operator stations using common AFSK at 1200 baud. Standard APRS-compatible beacons also periodically report status and health of the system. My involvement in the project also motivated me to get a vanity callsign to be used onboard, KY1GDC.

In December 2007 I completed my M.S. program in electrical engineering, and a few short weeks ago I began the search for my next hill to climb. As I speak with both up-and-coming tech startups and the big aerospace companies, it is my extra curricular activities that started with BIG BLUE they all want to hear more about.

What started out as volunteering a little extra time turned out to be much more. Much, much more time volunteered; much, much more gained. Every second invested continues to pay huge dividends in terms of the doors that have been opened and the opportunities afforded. I look forward to the next challenge and hope that I can someday repay the amateur radio community for all that it has given me. ■

The chase team poses with BIG BLUE II at the recovery site. Members of the team, Edge Of Space Sciences, and a film crew enjoy the moment.

ARISS Inspires A New Generation of Hams

The ARISS program continues to provide students around the world with exposure to amateur radio communications. N8MS tells the story of his Earth Science students in Coloma Junior High School in Michigan.

By Matt Severin,* N8MS

Ham radio has been a part of my Earth Science instruction since 1997, when I was first licensed in Virginia. My teacher-mentor and Elmer, Jim McCloud, KU4C, encouraged me to get my license because it had many applications in the Earth Science classes we both taught. Jim explained that with ham radio the students could get local and national weather updates, learn about the electromagnetic spectrum, and even communicate with one another while on field trips. Ham radio is an excellent tool to bring into the classroom and make science real!

In early 2006, astronauts aboard the International Space Station (ISS) released an old Russian Orlan spacesuit with a ham radio transmitter and internal sensors to measure temperature and battery power. SuitSat, as it was called, was designed to transmit its condition to the ground and the message could be heard using ham radios or VHF scanners. I thought this would be a great way to introduce my Astronomy class unit (I now teach at Coloma Junior High School, in Coloma, Michigan), so I brought a small handheld radio to class with the hopes of hearing SuitSat as it flew over Michigan. Although I wasn't successful in hearing the satellite, my class did happen to catch a conversation between a school in Canada and the astronauts aboard the International Space Station.

Hearing the QSO while at school inspired me to look into contacting the ISS. A few years back I had tried to work the space station, but was never successful. Looking back, I realized that all of my attempts were too late in the day, and the astronauts were probably sleeping.

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A total of 13 Coloma students have spoken to astronauts aboard the International Space Station.

After some online research, I learned that astronaut Bill McArthur was very active on the ham bands, and the chances of working the ISS were good. With a modest station consisting of a Radio Shack HTX-212 transceiver and a homemade 2-meter copper cactus antenna stuck in a bucket of sand on the roof of the school, I started monitoring the ISS downlink frequency of 145.800 MHz. As luck would have it, March 21, 2006 was a scheduled rest day for the astronauts on the ISS, and Bill McArthur, KC5ACR, began a marathon of ham radio contacts using the callsign NA1SS.

From 16:50 to 16:54 UTC (11:50 to 11:54 AM local time), 24 students in my fourth hour Earth Science class listened in on a short conversation between Bill McArthur and me. I was using my previous callsign, KG4EDK, at that time. When astronaut McArthur asked if any of my students were with me, 24 faces lit up with broad smiles as the students realized this was real: An astronaut 220 miles overhead was asking about them! McArthur stated, "We sure think Earth Science is important …we live it every day as we observe the Earth, and it's truly spectacular." The conversation ended with a motivational greeting from the International Space Station when Bill McArthur encouraged Coloma students to "… get the best education [they] can …"

Later that afternoon 13 more students had the opportunity to not only listen in on a conversation, but also participate in a contact! About 15 minutes before the

Since July of 2006, many of the Coloma students have earned their Technician license.

scheduled pass, I greeted my students with a note card and a task: Write down a question that you would ask an astronaut if given the opportunity. I established contact with the ISS at 19:58 UTC (2:58 PM local time) and passed the microphone to the first student, Monica, who asked, "What is the food like?" No one could keep a straight face when the microphone was passed to him or her. Even I had sore cheeks after the contact from smiling so much. In the end, each student who wanted to asked his or her question, and astronaut McArthur answered in great detail. McArthur described some of his daily activities, his favorite food (lamb with vegetables), and the level of education required to become an astronaut. The contact ended at 20:08 UTC (3:08 PM local time) as Bill McArthur's final transmission to Coloma Junior High School faded into the static.

"The students were really excited about the contact," said assistant principal Dave Ehlers. "My daughter ran down to my office to tell me that her class talked to the International Space Station." When asked if I had been trying to contact the station for awhile, I replied, "...well, actually no. I knew the opportunity was there, I had the right equipment, and I guess I got lucky." I added, "Never in my wildest dreams did I think I'd be able to provide this opportunity to my students. This was the ultimate teaching moment … I couldn't let it pass by."

Nathan Conrad, KD8FFT, was inspired to get his amateur radio license after talking to Bill McArthur, KC5ACR, aboard the ISS.

A homemade 2-meter copper cactus antenna stuck in a bucket of sand on the roof of the school. (All photos courtesy of the author)

As a result of working the ISS, four of my students earned their Technician Class licenses and became active in the local ham community.

Exactly six months later, I was again able to work the International Space Station from my classroom. While students were not able to actually talk to the astronauts, they were very excited to hear me talking to Anousheh Ansari, space participant, as the ISS soared over southwest Michigan. Ms. Ansari commented that she was very excited to talk to a school, especially since it was not a scheduled contact! A few days later, just before Ms. Ansari was to return to Earth, I was able to contact her one more time, this time with a different group of students. Coloma Junior High School was buzzing with excitement!

Later that semester, the Blossomland Amateur Radio Association (BARA) of Saint Joseph, Michigan offered a Technician class, and another five students from Coloma schools took and passed their Technician tests, making the number of new hams from Coloma schools nine. Currently seven more students are studying to take the Technician test, and three of the original nine plan to upgrade.

I'm very excited to see so much interest in amateur radio. There are so many opportunities for students who are involved in ham radio. Who knows? This may have sparked an interest in a student that he or she didn't even know existed!

Currently, I have worked the International Space Station four times from school with a total of 13 students actually talking to an astronaut aboard the ISS. I have started a new ham radio youth club, the Blossomland Youth Amateur Radio Club (W8BYC), and hope to see more students become involved in ham radio. Thanks to the Victor C. Clark Youth Incentive grant from the ARRL Foundation, I have been able to purchase radio equipment for use in the classroom.

While it's very exciting for me to work the ISS, it's even more fulfilling to see my students have an opportunity like this. As stated before, this was the ultimate teaching moment. I'm always looking for special opportunities for my students. I'm a teacher because in my heart I truly believe that it's all about the kids!

Visit the Blossomland Youth Amateur Radio website at: <http://www.w8byc.com>. You can listen to the astronauts' replies to me and my students at: <http://www.w8byc.com/ISS.html>. ■

By Bob Witte,* KØNR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

Report from Dayton

Photo 1. Jim McClellan, N5MIJ, speaks to a packed crowd at this year's Dayton Hamvention® D-STAR Forum. (All photos by KØNR)

The Dayton Hamvention® is the "big one," held in Dayton, Ohio in May and sponsored by the Dayton Amateur Radio Association (DARA). I was fortunate enough to attend the event again this year, and here is a report on some of the things I saw, with a VHF emphasis.

D-STAR Action

The VHF/UHF digital modulation format known as D-STAR continues to generate a high level of interest in the ham radio community. The D-STAR forum at Dayton was packed with attendees, even though it was held in one of the larger conference rooms. The forum was moderated by Greg Sarratt, W4OZK, with the Alabama D-STAR Group.

One major theme of the forum was the strong growth in D-STAR systems and users. According to Jim McClellan, N5MIJ, the number of D-STAR users showing up on the system has gone from 534 to 2400 in the past year (photo 1). The daily usage of gateway-connected D-STAR machines has gone from 100 users per day to 700 users per day. These numbers are small when compared to the total number of licensed amateurs, but they are growing at a very fast rate. To see the level of activity yourself, go to the D-STAR Users website listed in the References section of this column. This site has a real-time listing of stations active on D-STAR and plots of usage statistics on the D-STAR network.

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Photo 2. ICOM display of D-STAR handheld radios.

Photo 3. The AMSAT booth at Dayton had the usual AMSAT material and volunteers to answer questions about operating via satellites.

Photo 4. AMSAT satellite demonstration station in the parking lot.

Another key theme of the D-STAR forum was user education. D-STAR technology employs new methods of signal routing that your typical repeater user will need to learn. I won't go into great detail here, but I'll give you a rough idea of how the system works.

Each radio is programmed with four callsigns: MYCALL, URCALL, RPT1, and RPT2. MYCALL is the callsign of the radio user—that is, I program my radio with my call. URCALL is the radio amateur being contacted; it is the "other ham" in the QSO. You can enter a specific callsign as URCALL or use CQCQCQ to make a general call. RPT1 is generally the callsign of the repeater you are using locally, and RPT2 is a remote repeater. (This reminds me of programming an AX.25 packet TNC with your call and digipeater routing information.) There are a number of details that must be configured just right for the message routing to work, and I don't think anyone claims that this is obvious. It requires some learning on the part of the user, and you'll notice D-STAR system owners spending time educating their local radio community.

Most users are going to want to carefully set up their radios with the aid of programming software and use the memories to configured different callsign routing settings. Then flipping through

Photo 5. Carole Perry, WB2MGP, leads the Youth in Amateur Radio forum.

Photo 6. Ben Veltman, KD8GBY, of the ARGYL team demonstrating a light bulb used as an HT antenna.

memories will let the user call the right radio amateur or repeater system. With analog FM repeaters, the user has to select the right frequency, the right transmit offset, and (often) the right CTCSS access tone. Some users find this to be a challenge. With D-STAR you can forget the CTCSS tone, but you'll also need to set up URCALL, RPT1, and RPT2 to get the right thing to happen. (MYCALL generally will just stay the same on a particular radio.)

There is no question that D-STAR really is a different animal, and it requires some learning on the part of repeater users. This is typical of new technology entering ham radio and is a fun part of the hobby. The D-STAR presentations given at Dayton are available on the ARRL Alabama Section website (see References), including information on the callsign settings. If you are interested in this technology, take some time to review those files.

One important development is that some technically-minded hams have reverse-engineered the D-STAR protocol, including specific ICOM implementation details. Robin Cutshaw, AA4RC, touched on this briefly in his presentation and a portion of his talk is available on youtube.com (see URL in References). One product that came out of this work is the DV Dongle, which enables a PC user to converse via the D-STAR network. Yes, that's right: You can be sitting at your PC working radio hams on your favorite D-STAR repeater. This development shows that others (besides ICOM) can create products that conform to the D-STAR protocol and work with D-STAR radios and repeaters.

Inside the Hall

AMSAT was very visible at the Hamvention® with its large booth, AMSAT forum, and satellite demonstrations in the parking lot *(for more details on AMSAT at Dayton, see the "Satellites" column by Keith Pugh, W5IU, elsewhere in this issue—ed.)*. At the booth in the Hara Arena were the usual AMSAT trinkets and a model of the Eagle satellite under development (photo 3). Also on display was the Software Defined Transponder (SDX) hardware, likely to be used on the SuitSat-2 satellite. Out in the parking lot, Keith, W5IU, used a homebrew antenna and FT-817 to demonstrate working the satellites (photo 4).

Many people commented that the number of new product introductions at Dayton seemed a bit light this year. I tend to agree, especially from an FM VHF point of view. One rig that caught my attention, though, was a prototype of the Yaesu VX-8R, described as "everything the VX-7R has plus 222 MHz and APRS." It also has an optional GPS receiver and optional Bluetooth® hands-free capability. Of course, it always good to see multiband radios offering 222-MHz operation. More interesting is that Yaesu has put APRS into this radio as a standard feature. Previously, Kenwood had the built-in APRS market to

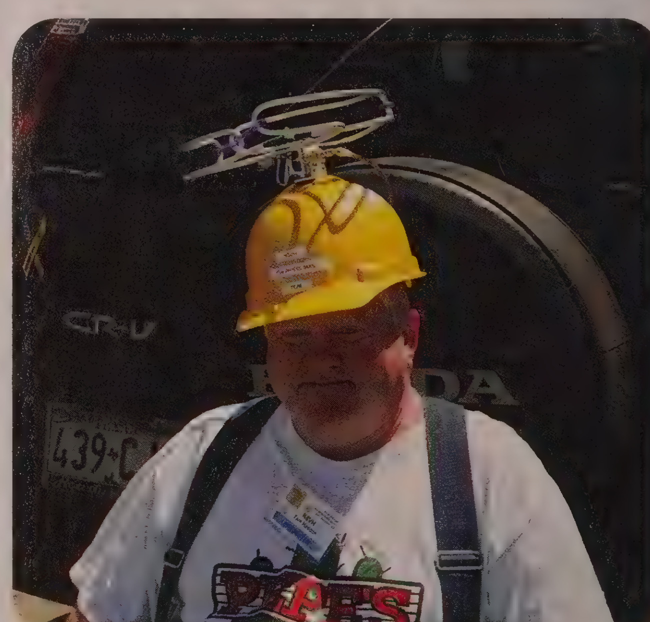

Photo 7. Tom Haddon, K5VH, demonstrates his omni-directional horizontal antennas by wearing one on his helmet.

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Hams Help Fliers, Boaters, and Hikers One ELT at a Time

Kerry "Hutch" Hutcheson, KE7JFQ, was almost asleep as his wife drove along Interstate 5 near Roseburg, Oregon on June 7. As they crested a hill, the car was suddenly filled with a siren-like sound. At first they thought the Highway Patrol was behind them. Then they realized that it was the audio of an aircraft Emergency Locator Transmitter (ELT) on Hutch's mobile transceiver, which was tuned to 121.5 MHz.

Knowing that this transmission would soon be picked up by USA's SARSAT and Russia's COSPAS satellites, and an alert by the Air Force Rescue Coordination Center would follow, KE7JFQ went into action. Following his Amateur Radio Emergency Service (ARES) training, he reported the situation to the Roseburg 911 dispatcher. Then he called his friend and fellow ARES member Jerry Eifert, KB7WDR. Together they tracked the signal and soon found themselves at the Roseburg Regional Airport hangar (photos 2 and 3).

KB7WDR picks up the story: "I took the antenna off my hand-held and walked around the metal building. By one door there was an opening in the metal and the meter went crazy. Farther down from that door was a workbench where the unit turned out to be. It was strong even through the metal there.

"Nobody was in the hangar, so we found an airport employee who came up with a list of the tenants. I called the owner and got an answering machine. I left a message that this was Search and Rescue (SAR) from the Douglas County Sheriff's office and there was a squawking ELT in his hangar. It had to

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Photo 2. Kerry "Hutch" Hutcheson, KE7JFQ, sets his vehicle for 4-wheel drive on a mission for Douglas County ARES. Hutch was recently lauded by the sheriff's office for discovering a squawking ELT at Roseburg Regional Airport. (Photo by Jerry Eifert, KB7WDR)

Photo 1. Old-style Emergency Locator Transmitters like this one are still installed in thousands of commercial and private aircraft. They do not transmit an ID or GPS coordinates, so they must be tracked by RDF when activated. (Photo by Tom Curlee, WB6UZZ)

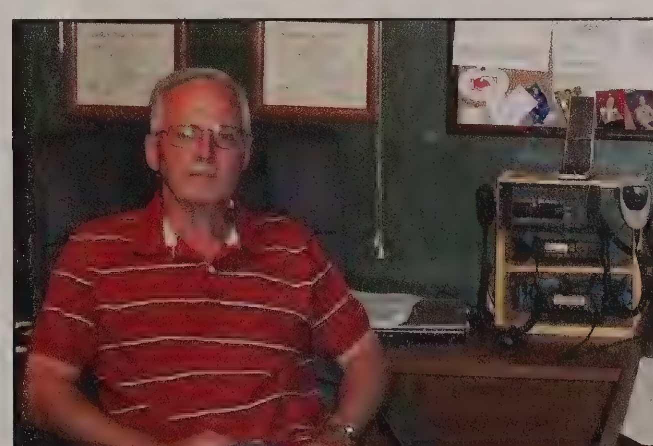

Photo 3. Jerry Eifert, KB7WDR, worked with KE7JFQ to pinpoint the location of the ELT false alarm at Roseburg Airport. He has also tracked down several other activated ELTs and EPIRBs in recent months. (Photo courtesy of KB7WDR)

be shut off, so if I didn't get a call back from him soon, we were going to break the lock. Within five minutes sheriff's dispatch called to say he was on the way.

"The owner was a 70-year-old guy. He had crashed his experimental plane through a fence into a Motel 6 parking lot a few days before. Then he had picked up all the pieces and put them in this hangar. Some friends were helping him clean up, and one of them saw this little 'radio-looking' thing and picked it up. He flipped the switch to ON and when it didn't make any sound, he set it down on the bench and left it."

Photo 4. The LL-16 Little L-Per by L-Tronics is popular with Civil Air Patrol and other agencies that are responsible for ELT/EPIRB/PLB tracking. (Photo by KØOV)

Emergency Beacons as an ARES Mission

There are well over a half-million aircraft ELTs, maritime Emergency Position Indicating Radio Beacons (EPIRBs), and Part 95H Personal Locator Beacons (PLBs) in the hands of pilots, boaters, and outdoors enthusiasts. When activated manually or by an impact sensor, they transmit continuously on 121.5 and 243.0 MHz AM until the batteries fail or they are turned off. The newest ones also send a registration number and GPS coordinates digitally on 460.025 MHz.

Even though the nationwide percentage of "false alarm" activations is in the high 90s, the authorities consider any ELT, EPIRB, or PLB signal to be an emergency until proven otherwise. Even if there is no threat to life, a squawking beacon must be turned off as soon as possible because it is being heard and reported by commercial aircraft passing overhead. What's worse, the false alarm might cover up a weaker, but genuine distress signal.

"It's good that we got it shut off before the Air Force triggered a mission," Jerry explained. "Our own sheriff's dispatchers didn't understand the seriousness until they relayed the call to Oregon Emergency Response up in Salem. Those people got really hot about it. They said, 'We want it off right now! We also want the tail number of the plane and the serial number of the ELT.'"

In southern California, where I live, most ELT activations are investigated by Civil Air Patrol staff and volunteers. That's true in many other locations, but not central Oregon. "There isn't a big CAP presence to cover Oregon," says Wayne Stinson, Emergency Services Coordinator for Douglas County. "It could take quite a while to get a CAP representative or team in from another area. We just take the task and run with it, as do many county sheriffs in the state.

Douglas County encompasses 5000 square miles and extends from the coast at Reedsport to Howlock Mountain and Crater Lake. Stinson is grateful to have a well-organized group of hams to help him. "We work very closely with our ARES folks on search/rescue and disaster preparedness," Stinson told me. "We know that you can burn out volunteers, but if you don't give them some meaningful tasks, they tend not to be around when you need them."

Stinson continues, "The ARES group sets up our county Emergency Operations Center with telephones, network cables, and all that. It fits very nicely into their area of interest and expertise. They are also involved with the hospitals and Red Cross. A while back, they showed us that they can help with emergency beacons, too. They are used to doing foxhunting and that is very applicable. Most of our active ARES folks now monitor 121.5 MHz.

"An ELT came up in the middle of the night a couple of years ago. We called it a burglary detection tool. Our amateur folks tracked it to an apartment building and called law enforcement to knock on the door for them. The lady who answered said, 'I don't have anything like that,' but after further questioning, her son came out of his room looking sheepish. The deputy started asking him questions and sure enough, he had it stashed in his room. One of the other residents had stolen a bunch of equipment out of an airplane. We not only got the ELT and shut it off, but we closed a criminal case."

Stinson says he is proud of the way the hams handled this activation. "It's not just that they went out and took care of it, but that they did it in the right way. After they picked up the signal, they called dispatch and said who they were, what was going on, and where they were going to be. They weren't being cowboys. I wasn't notified until I came to work the next day because they handled it right."

A Boat in the Mountains

It has been a busy time for KE7JFQ, KB7WDR, and other Douglas County ARES members. "We have had four ELTs in the last nine months," says Jerry. "One of our members was driving I-5 north of Roseburg and heard one. A seaplane had landed on the river and the pilot's knee had bumped it when he got out. We got that one quickly before the Air Force called.

"Another one had us out until about 3:30 AM. There was an abandoned 40-foot ocean-going vessel up in the mountains. Someone found a big old buoy inside. There was a switch on it marked ON and AUTO. He flipped it to ON and nothing happened, so he heaved it into the back of his pickup, drove home, and parked it in his garage. I got to his property in the middle of the night, got the man's name from the mailbox, and phoned him. As I told him that we were with the sheriff's department and there was an EPIRB transmitting from his truck, I could hear his wife yelling, 'I told you so!'

"He said he'd turn it off in the morning, but I answered, 'No, you're going to turn it off right now. Every commercial airliner going over tonight is reporting it

Photo 5. The Tracker FTV468C from Finland features a miniaturized VHF directional antenna with serpentine traces on circuit board material. (Photo by KØOV)

to Seattle center.' Finally he came out in his bathrobe. We took the buoy apart and got the battery out. It's our policy to insist on the battery being removed to make sure that it doesn't get accidentally turned on again.

"A couple of weeks ago we had an EPIRB activation in Reedsport, down on the coast. That one was in a ship repair yard. Again, someone had turned this 'radio' on and it didn't make a sound, so he threw it into a dumpster. We got there and found it at about 3 AM.

"We are so fortunate to have Wayne Stinson as our Emergency Manager," Jerry adds. "In some Oregon counties, the Emergency Manager doesn't want anything to do with ham radio. We do a lot of tasks for him, such as programming the department's radios and bringing new patrol cars down from Salem. In return, we have access to facilities and equipment when we need it. If we have to get up to one of our ARES repeaters in the winter, we can use Sheriff's department's snow cat.

"When we go out on ELT searches in the middle of the night, we want to look as official as possible, so we take the sheriff's Suburban. That is particularly important out around Hubbard Creek, which is a very rural and rough area. It's nice to have the red and blue lights and the star on the side when you're prowling around people's property. When they see that, they are less likely to think that you're there to steal something."

Although the newest emergency beacons send their location coordinates from an on-board GPS unit, the Douglas County hams tell me that to date they have not encountered one of them. The anonymous ELTs, EPIRBs, and PLBs that make up the vast majority of beacons still in use only transmit 100 milliwatts on 121.5 MHz with a strong second harmonic on 243.0 MHz.

Since the 1970s, the most popular radio-direction-finding (RDF) devices for 121.5 and 243 MHz have been made by L-Tronics Company of Santa Barbara, California.[1] Almost every CAP unit has one or more of the classic LH-10 "Little L-Pers." That model has a four-channel VHF/AM crystal-controlled receiver and a pair of phased vertical dipoles on a wooden frame. The antennas are switched by diodes to produce alternating left and right cardioid directional patterns. Signal strengths from each pattern are compared and the meter swings toward the signal. The user turns in the direction of the meter needle until it goes to dead center, at which time he or she is facing the signal. The zero-center direction indication is very sharp and sensitive.

Parts for classic L-Pers have become hard to procure in this decade, so L-Tronics stopped making them and saved the parts stock for servicing the large number of units still in use. The second generation model LL-16 (photo 4) became available in early 2006. It has the same left-right RDF indication, but it has a big step up in features, including synthesized frequency coverage from 108–174 and 215–270 MHz, built-in antennas, AM and FM detection, and a waterproof case that floats.

During the transition time when new L-Pers were unavailable, a company in Finland made inroads into the USA's beacon-tracking market (photo 5). RDF sets by Tracker Radio Location Systems[2] fea-

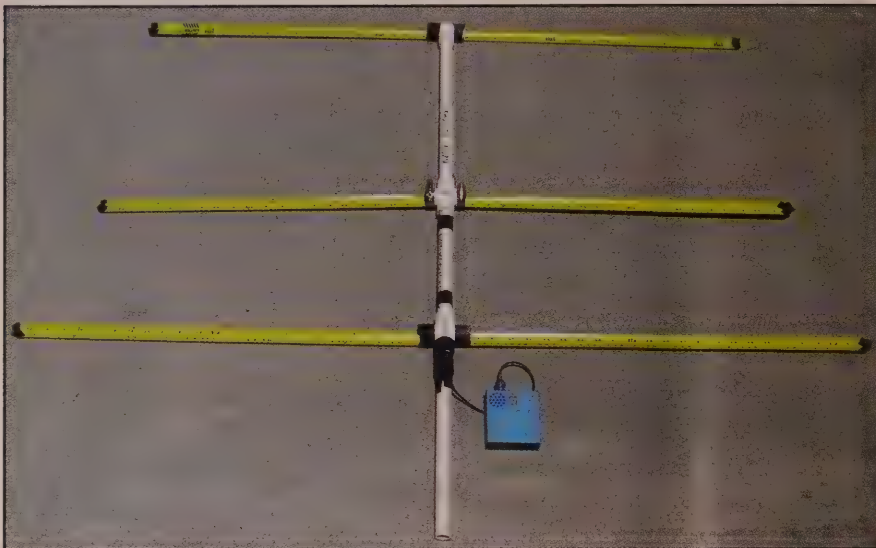

Photo 6. The author's on-foot RDF system for VHF emergency beacons consists of a three-element tape-measure Yagi and Sniffer4 receiver. (Photo by KØOV)

Measurement	Inches
Reflector (R) length	49 7/8
Driven Element (DE) length	43 1/4
Director (D) length	41 3/4
R-to-DE spacing	9 7/8
D-to-DE spacing	15

Table 1. Dimensions for a WB2HOL measuring-tape Yagi scaled for 121.5 MHz.

ture a receiver with attenuator that also serves as the boom of a two-element directional antenna. With physical element lengths of only 0.17 wavelength and element spacing of 0.08 wavelength, the fold-out beam falls short of the gain and capture area of a standard 121.5-MHz Yagi, but directivity is good. The Tracker FTV can quickly close in on an emergency beacon once it is in range of the signal.

The Douglas County Sheriff's office owns an L-Per and a Tracker, which are available to the ARES hams when needed. KB7WDR says that it's good to be able to use them, but he often goes without because it takes extra time to fetch them from the sheriff's shop. In some cases, he has had to complete the hunt for an emergency beacon by taking off the antenna and probing with his hand-held radio, tuning off frequency to knock down the signal.

ELT Tracking on a Budget

At $750 for new L-Per LL-16s and $600 for new Tracker FTV468Cs, very few hams will buy them for themselves. However, there are low-cost options for do-it-yourselfers that work just as well as, and in some cases better than, the commercial units. For instance, a three-element measuring-tape Yagi provides excellent gain and directivity. Its flexible elements are ideal for poking around in the brush. The popular 2-meter design by Joe Leggio, WB2HOL[3] won't work on the VHF aircraft band as is, but it is easily scaled to that range by lengthening the elements and increasing the spacing in proportion to the frequency ratio.

In photo 6 is a measuring-tape Yagi for 121.5 MHz. Dimensions are in Table 1. Be sure to include the hairpin matching wire as described on WB2HOL's site. I recommend wrapping eight turns of coax around the boom behind the reflector as a choke balun. This prevents pattern distortion that can be caused by signal pickup on the coax shield.

For a ready-made aircraft-band beam, take a look at the website of Bob Miller, N6ZHZ.[4] Bob has tracked dozens of emergency beacons as a member of Bracket Composite Squadron 64 of CAP in La Verne, California. He sells fold-up Yagis for 121.5 MHz and other VHF/ UHF bands. Each is built and tuned to order.

Many amateur radio handie-talkies will receive the VHF aircraft band. When shopping, look for a model with an AM receiving mode and check the specifications to make sure that the radio has full sensitivity outside the ham bands. Wide-range multi-mode receivers such as the ICOM IC-R10 are another good choice. In either case, an S-meter is an important feature for RDF. An external offset attenuator[5] is easy to build and works much better than tuning off-frequency for knocking down strong signals.

A favorite among international-rules foxhunting fans on 2 meters, the Sniffer4 receiver by Bryan Ackerly, VK3YNG, also covers 120 to 123 MHz (photo 7). Separate detectors for AM and FM signals are built in, as is an automatic attenuation system with 15-dB steps and a single-digit readout to display the current attenuation range. With the tone-pitch signal-strength indication in one ear and the ELT audio in the other on stereo headphones, you can keep your eyes on where you're walking as you travel toward the target.

My full review of Sniffer4 is in "Homing In" in the Fall 2007 issue of *CQ VHF*. The instruction manual is available on the web.[6] Depending on the currency exchange rate and method of shipping to the USA, a Sniffer4 costs between US$220 and US$250. It is available directly from VK3YNG in Australia[7] and also from Bob Miller, N6ZHZ, in southern California.[8]

Whatever RDF method you choose, get some practice with it before you need to find a real emergency beacon. KB7WDR says that Douglas County ARES has a formal transmitter hunt for training and fun at least once a year. "One of our members converted an old ELT over to FM on 2 meters," he explains. "It makes the same siren sound. After an ARES meeting, somebody goes out five or ten miles and turns it on. Then we have a contest to see who finds it first."

Jerry proudly told me about a new UHF repeater and remote base system that his group is constructing. "It's going up on a 1650-foot mountain. The VHF transceiver can be switched remotely to link us into repeaters at Salem, Corvallis, Eugene, Grants Pass, Coos Bay, Bend, and Winchester Bay. Our county's radio system relies on microwave for long haul, so communications can fail if a heavy wind moves the dishes out of alignment. That happened last winter and they lost radio contact with deputies on the coast. Our system will be able to back that up."

That's great, but I think the remote system could be even better if it included ELT/EPIRB/PLB monitoring capability. More ARES members would be alerted to emergency beacons as they come on, and at much greater range. Such a system has been in regular use by hams in Santa Barbara County, California since 1989 to provide early detection and facilitate

Photo 7. For ELT/EPIRB/PLB tracking, Bob Miller, N6ZHZ, prefers the folding three-element beam and VK3YNG Sniffer4 that he is holding, because this high-sensitivity system provides maximum range. The rotating Yagi atop his truck is for 2-meter transmitter hunting. In its place, he can mount his home-built cubical quad for 121/243 MHz. (Photo by KØOV)

rapid response by the volunteers of Santa Barbara Search and Rescue (SBSAR).

Repeaters as ELT Sentinels

The driving force behind the Santa Barbara County ELT Monitoring System has been the team of Bruce Gordon, N6OLT, and Lou Dartanner, N6ZKJ, who are the founders and owners of L-Tronics Corporation. N6OLT says that the remote monitors are based on the classic L-Per receiver. "We took advantage of its sensitive detection system," he says. "It makes use of the fact that 121.5 and 243 have 100-kHz guard bands. We switch the receiver between 121.5 and 121.46 and do a comparison between noise levels. Broadband noise will tend to be equal on each frequency, but any signal will change that. This method detects and alarms on very weak signals that you can just barely make out by ear."

When a signal is detected, the repeater sends an audio tone that opens the squelch on SBSAR members' receivers. Bruce explains that there is a delay before alarm of ten minutes because of the voice traffic on 121.5 and 243 MHz. "I heard three instances of it just this morning, such as Air Traffic Control telling a pilot what frequency to go to for landing instructions. Perhaps the guy dropped his map book on the floor of the cockpit and couldn't get to it, so he called on 121.5 for information."

Besides being able to "snooze" the alarm, users can command the repeaters to retransmit the audio from the emergency beacon receiver. "This is absolutely essential and quite interesting," Bruce says. "For instance, if we hear a brief interruption, we know that it is sending data on 406.025 MHz. We can also learn a lot from the building and fading of the signal. We compare that with the marine weather report of the wave rate in the channel. One EPIRB turned out to be beached up on the rocks. It was at the surf line, so it was bobbing at twice the wave rate.

"By listening to how it builds and fades through the system, we can usually determine if an ELT has activated inside a moving airplane. That is not unusual. We typically have about one a week and we can tell the controllers that it's headed for Los Angeles or San Francisco by which receivers hear it when. If there are sudden jumps, then somebody may be working on it or walking by it at an airport. On two occasions we heard irregular flutter that turned out to be passing cars on a street."

Today there are six receivers in the Santa Barbara system. Four are at mountaintop repeater sites, one is near the harbor, and one is close to the airport. All are listening to 121.5 MHz. Four also monitor 243.0 MHz and one has a receiver for the new digital EPIRBs on 460.025 MHz.

The system proved its worth immediately after installation. On the second day it alerted hams to an EPIRB floating in the ocean, 22 miles offshore. In the following ten years, 315 alarms were recorded. Six were aviation emergencies and three were marine emergencies. Most of the rest were false alarms or inadvertent activations similar to the Oregon stories above. Some disappeared before being found, perhaps being discovered by their owners or moving out of range in an aircraft or vessel.

Besides its lifesaving potential, a monitoring system like this is a money saver for taxpayers. Between 1989 and 2002, SBSAR was alerted by the Air Force Rescue Coordination Center of ELT/EPIRB/PLB satellite "hits" in the vicinity only three times. The rest of the time the monitoring system made it possible to silence the transmissions before a federal alert was necessary.

SBSAR continues to upgrade the system. "We have a project to utilize the data burst from the new 406 beacons," Bruce told me. "The first unit is going into the repeater in downtown Santa Barbara. It decodes the ID and GPS information and generates a RS232 data stream, which we can put out on packet. We might also turn it into a text message to be sent to cell phones and pagers."

Who responds to emergency beacon transmissions in your area? Could these responders use your help? Investigate, and you might discover an opportunity to use your RDF skills to help your community and perhaps save lives.

73, Joe, KØOV

Notes

1. http://www.ltronics.com/
2. http://www.trackerradio.com/search-rescue-tracking/index.asp
3. http://home.att.net/~jleggio/projects/rdf/tape_bm.htm
4. http://www.rdfantennas.com/bc146Antenna.htm
5. http://www.homingin.com/joek0ov/offatten.html
6. http://www.users.bigpond.net.au/vk3yng/foxhunt/2m_sniffer/manual.htm
7. http://www.users.bigpond.net.au/vk3yng/foxhunt/foxhunt.html
8. http://www.rdfantennas.com

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Field Day Balloons

Field Day is a great time to demonstrate the amazing capabilities of high-altitude balloon payloads. Each year I try to fly something different that we can show to the public at the Huntsville Amateur Radio Club's Field Day site. The site is uniquely positioned in a field next to Space Camp, which always attracts quite a number of curious Space Campers and their families. I've found that balloon flights into near space definitely get their attention.

Since Field Day's main goal (in addition to the goal of eating tons of great food!) is to demonstrate emergency communications, this year I flew a 2-meter FM simplex voice repeater. From its vantage point over 100,000 feet above the Earth, this repeater would cover a great majority of the Southeast and Midwest. What better way to demonstrate wide-area emergency communications using low-power ground stations?

Simplex Repeater

A simplex repeater is a fairly easy thing to put together, consisting of just two things: a handheld radio and a voice record/playback unit. A few years ago, RadioShack sold a great module that made this a plug-n-play solution. Sadly, it discontinued the unit, so I've been relying on the increasingly rare eBay find for these. Fortunately, Scott Miller, N1VG, of Argent Data Systems (http://www. argentdata.com/catalog/) stepped in to fill the gap and introduced the ADS-SR1 simplex repeater module at the Dayton Hamvention® this year (see photo 1). Scott added quite a few bells and whistles to his version. Through touch-tone commands, you can set up voice and CW ID announcements, voice-mailboxes, and a host of other features, including up to 218 seconds of record time. However, due to the amount of traffic expected through the repeater, I chose to limit the record and playback time to 24-second intervals. Just hook up the interconnect cable from the ADS-SR1 to your handheld radio (I recommend using Eveready® lithium AA batteries), adjust the audio levels for best audio quality, stuff it all into a Styrofoam™ box with lots of duct tape, and you're ready to fly.

Although you can use the simplex repeater module with any HT (Argent makes a variety of interface cables for various HT models), I've had great results with several of the Alinco family. The dual-band Alinco DJ-C7T is very easy to interface and is very lightweight and rugged. Since it has an SMA connector, I find that the Comet SMA-24 whip antenna works well

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Photo 1. Argent Data System's ADS-SR1 simplex repeater. (Photo courtesy of Argent Data)

Photo 2. Alinco DJ-S11T with vertical dipole modification.

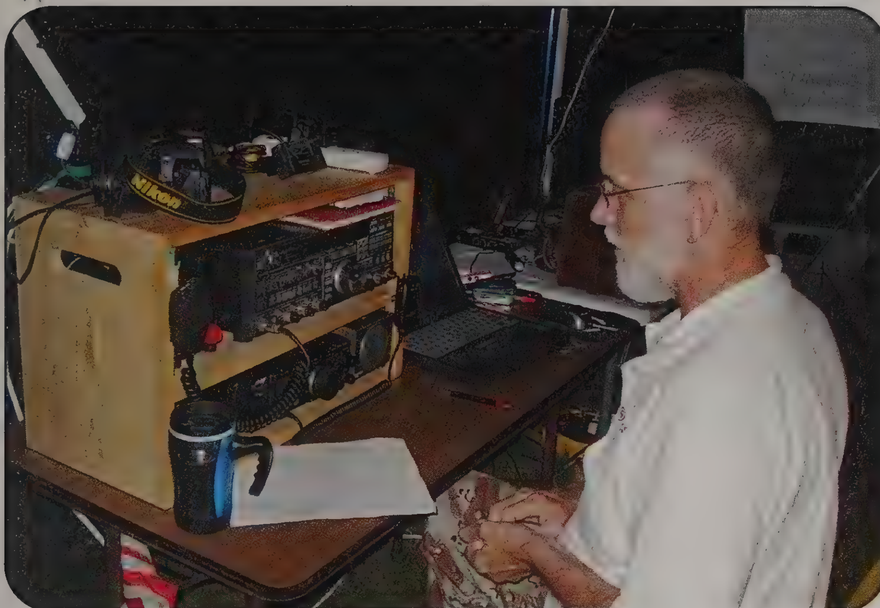

Photo 3. Alan Sieg, WB5RMG, operates the balloon net control at the Huntsville Amateur Radio Club's Field Day site.

with it. However, I do recommend powering the DJ-C7T from an external 6-volt lithium battery pack for maximum operating time and to also increase the output power to 500 mW. Another Alinco radio I've had great success with for balloon flights is the very inexpensive and lightweight DJ-S11T. You won't need an external battery pack for this radio, since it's already designed to use internal AA batteries. I once lost a payload carrying two of these radios. Seven months after my flight, a hunter found it lying in a mud puddle covered in fire ants. I powered up

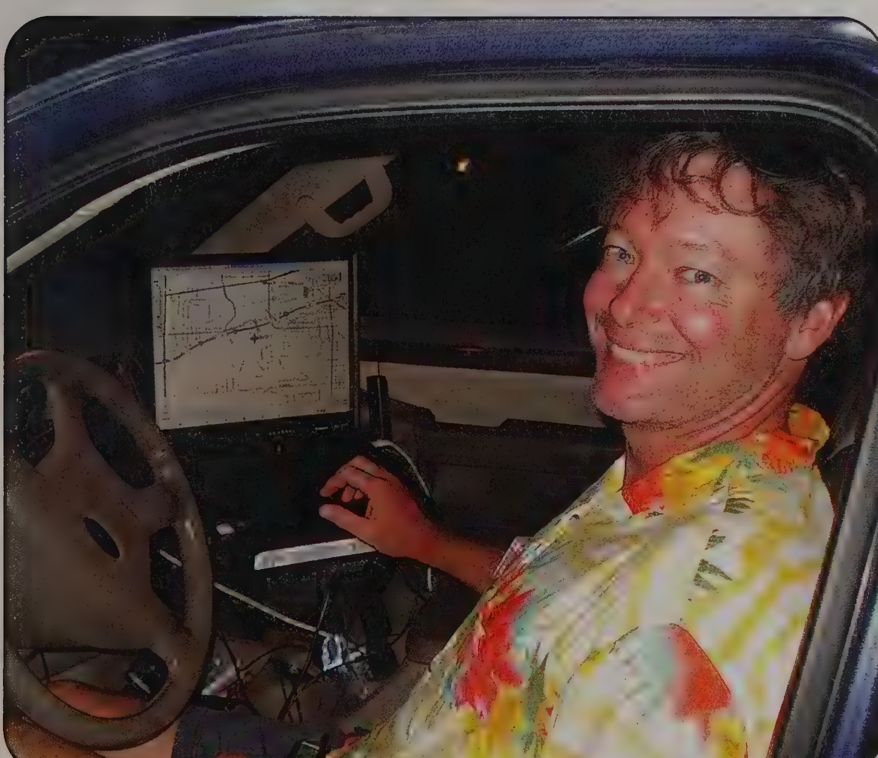

Photo 4. Shane Wilson, N4XWC, tracking the balloon on mobile APRS.

the radios and they worked just fine after months of abuse.

However, I do have one recommended modification if you plan to use a DJ-S11T. The tiny whip antenna that comes permanently installed in the radio is terribly inefficient. I usually remove it and just solder two 19-inch wires to the antenna pads inside the radio and then tape the wires to a small wood or carbon-fiber dowel rod taped to the side of the radio to create a half-wave vertical dipole. You could also just install an SMA connector instead to use an antenna of your choice. In either case, you'll be amazed at the difference. Photo 2 shows the DJ-S11T with the vertical dipole modification.

The Repeater Flight

We launched the simplex repeater along with two Byonics Microtrak 300 APRS trackers. One used the Deluo GPS receiver (N4XWC-11) and the other used the Garmin GPS18-LVC (WB8ELK-11). Not all GPS receivers will work above 60,000 feet, and as expected, the Deluo unit died at 78,856 feet. Fortunately, the Garmin unit worked just fine as we reached a peak altitude of 115,078 feet.

Our net controllers (Gary Dion, N4TXI, and Alan Sieg, WB5RMG) were operating from the K4BFT (K4 Big Fat Turkey) Huntsville Field Day site (see photo 3). The audio quality through the simplex repeater was excellent, and dozens of contacts were made over a wide area of the Southeast and Midwest. Contacts were made with Field Day sites in Marietta, GA (W4LKL), Columbia, TN (KE4KVC), and Bowling Green, KY (W4HTB at KY4BG). In addition, we contacted Bob, KA9UVY, in Mt. Vernon, IL, who reported a full-scale S-meter report from 300 miles away. I was able to make a mobile-to-mobile contact with Shannon, KC9BIE, in Mt. Vernon, IL as well. It's truly amazing what a 300-milliwatt radio will do if you put a 115,000-foot tall antenna on it!

The Chase

At one point the balloon flew directly over Space Camp (22 miles above it), so we knew it would be landing fairly close to us. After the payload started its parachute descent, Shane, N4XWC (see photo 4), and I set out on the chase and watched anxiously as the payload crept closer and closer to the edge of the Redstone Arsenal Army base. Sure enough, it decided to give the 1000-acre treeless dirt field a miss and flew across the road to land in the top of a tree just a couple of hundred feet inside the arsenal, which is surrounded by barbed wire fences. We decided that the Army would take a dim view of our scaling the fence to recover the payload, so I'll be having a nice chat soon with the MPs to see if they'll let me in there. In the meantime, as I write this in early July, the simplex repeater has been operating for a couple of days, still happily repeating whatever it hears from its treetop perch.

Since we were thwarted in our attempt to recover the repeater balloon, Shane, N4XWC, Dick, W1TV, and I decided to track down the ozone sounding balloon launched just before our flight. It's a tricky beast to track, since it's wideband FM on 403 MHz and drifts like crazy. We drove around the area for an hour and all of a sudden heard it loud and strong. Since there was no GPS onboard, we had to use traditional direction-finding (DFing) to find it. Sure enough, we triangulated it to the rooftop of a large warehouse in downtown Huntsville. We now know where two balloon payloads have landed, but so far there is no way to get to them. Although we returned to the Field Day site empty-handed, we sure did have a lot of fun chasing them.

More Field Day Balloons

This year there were two other balloon missions flown for Field Day: Near Space Ventures of Kansas City (WØNSV-11) flew an APRS tracker with a simplex repeater, and Taylor University in conjunction with the Ft. Wayne Radio Club in Indiana flew an APRS tracker (KB9ZNZ-11) and a crossband 2m/70cm FM repeater. Three more groups had plans to fly for Field Day but had to scrub them: Tennessee Balloon Group (TABEL), Surfing Satellites of Ohio, and Ballon Radio-amateur du Quebec (BRAQ).

Next year it is my hope that we will see Field Day balloons popping up all over the country. Just imagine the emergency communications possibilities that would demonstrate. To find out if a balloon is launching in your area, just check the ARHAB (Amateur Radio High Altitude Ballooning) website at: <http://www.arhab.org>.

73, Bill, WB8ELK

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Bouncing VHF Signals Off "Shooting Stars"

Several times each year, VHF enthusiasts are presented with the exotic operating opportunity created by shooting stars. The intense ionization caused by a meteor's demise as it burns its way into our atmosphere can be enough to reflect or refract VHF radio signals, making radio communication between two stations beyond line-of-sight possible, if only for a very short moment.

Reflecting VHF radio signals off meteor trails during one of the year's annual meteor showers is an activity that has been enjoyed for decades. Yet new methods and techniques are developed and explored, using modern computing power. The newest tools even allow radio contact during periods outside the major meteor showers.

During major meteor showers it is typical for hundreds of two-way contacts (QSOs) to be made. I've even had the joy of making a few quick contacts between my meager station (a vertical mobile antenna tuned for 6 meters with 100 watts on SSB) and stations up to two states away. This was accomplished during the *Leonids* meteor shower a few years ago. With the newest software tools, and with good equipment and a good antenna, along with prearranged schedules, many amateur radio weak-signal communicators make quite a few contacts all year long.

Most schedules in North America between VHF meteor-scatter DXers are for SSB QSO's. When using SSB, a 15-second sequence is standard in which the western-most station calls first, and the rest of the minute is spent listening for the reply from the called station. Most often a QSO is completed on a long burn lasting several seconds. However, because most meteors only last close to a quarter second to a couple of seconds, there's usually not nearly enough time to get much information through on SSB.

This is overcome by using high-speed CW. If you tried to keep a 2-meter meteor-scatter schedule with a station 1000 miles away, you might hear five to ten short "pings" (a burst of radio propagation caused by the rapidly formed and short-lived meteor-trail ionization) lasting anywhere from a tenth of a second up to two seconds in length. A ping under a half of a second would be absolutely useless on sideband. Enter high-speed CW. With HSCW, you could realize a speed of 2000 letters per minute (2000 lpm). In that same half-second ping 16 letters could be propagated to the receiving station. That is enough for a complete exchange and signal report! High-speed CW is more commonly called high- speed meteor scatter, or HSMS.

To ensure that only one station is transmitting at a time during a schedule, HSMS stations in North America transmit on alternate minutes. Typically, the westernmost station transmits on the even-numbered minutes while the easternmost station transmits on the odd-numbered minutes. During that minute, a meteor may fly between the two stations and briefly reflect a VHF radio signal. The QSO is completed when both stations have heard each other's callsign, a signal report (or some other piece of information), and the final "Roger." On 2 meters, schedules usually last a half hour to one hour. I'll dig deeper into this mode later in the column.

Working Meteor-Scatter Mode

Meteors are particles (debris from a passing comet) ranging in size from a spec of dust to a small pebble, and some move slowly while others move fast. When you view a meteor, you typically see a streak that persists for a little while after the meteor vanishes. This streak is called the "train" and is basically a trail of glowing plasma left in the wake of the meteor. Meteors enter Earth's atmosphere traveling at speeds sometimes well over 158,000 miles per hour. The trains can last from several seconds to several minutes.

Meteor-scatter propagation is a mode in which radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the E-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains. On the lower frequencies, such as 6 meters, contacts may last from mere seconds to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. A meteor train that supports a 60-second refraction on 6 meters might only support a one-second refraction for a 2-meter signal. Special high-speed methods are used on these higher frequencies to take advantage of the limited available time.

A great introduction by Shelby Ennis, W8WN, on working meteor scatter can be found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. W4VHF has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm >.

The *Perseids* Meteor Shower

One of the most reliable yearly meteor showers is the *Perseids*. The *Perseids* meteor shower, like other meteor showers, is named after the constellation from which it first appeared to have come. This shower's constellation is Perseus, which is located near Cassiopeia. *Perseids* favor northern latitudes. Because of the way Comet Swift-Tuttle's orbit is tilted, its dust falls on Earth's Northern Hemisphere. Meteors stream out of the constellation Perseus, which is barely visible south of the equator.

Lewis Swift and Horace Tuttle, Americans working independently, discovered a comet in August 1862. Three

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years later, Giovanni Schiaparelli (of Martian "canali" fame) realized it was the source of the August *Perseids* meteors. The comet, known now as Comet Swift-Tuttle, leaves a trail of dust that Earth passes through during August.

This year the shower will be active from July 17 through August 24. The peak is expected to be around August 12, between 1130 UTC and 1400 UTC. The number of visual meteors is expected to be about 100 per hour. It is possible, using high-speed CW, to realize a higher hourly rate, since many meteors that are not visible might contribute to the ionization necessary for long-distance contacts.

The *Perseids* shower begins slowly in mid-July, featuring dust-size meteoroids hitting the atmosphere. As we get closer to August 12, the rate builds. For working VHF/UHF meteor scatter, this could prove to be an exciting event.

There is a slight possibility that there will be a secondary peak around 1640 UTC on August 12. This is based on data collected in the 1990s which revealed an annual shift in the solar longitude of the "old" primary peak. This secondary peak has not been observed since 1999, however. Also, because the comit's orbital period is about 130 years, it is now receding back into the outer solar system. This means that the rate will slowly dwindle for a significant number of years, and, the secondary peak will be rare. Nevertheless, be aware that it still could occur this year.

The best time for working the *Perseids* VHF/UHF meteor scatter in North America is during the hours before dawn, as early as midnight, but more likely peaking after 2:00 AM until about 5:00 AM local time.

The characteristic *Perseids* burn is bright white or yellow and typically lasts less than a half second. The brighter meteors usually leave a persistent train, or "smoke trail," that lasts a second or two after the meteor has vanished. This is not really smoke at all, but rather ionized gas created by the meteor passing through the atmosphere at tremendous velocities. It is this trail that potentially reflects the VHF radio signal.

Setting Up a *Perseids* VHF Schedule

If you have a reasonably-powered computer, with a sound card, you could try your hand at high-speed CW meteor scatter during the *Perseids* shower. Visit <http://www.vhfdx.de/wsjt/> to obtain your copy of the WSJT computer program. WSJT stands for "Weak Signal communication, by K1JT." This program was created by Joe Taylor, a 1993 Nobel Laureate in Physics for the discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation.

The program currently supports four principal modes, two of which are primarily useful for weak-signal communications via the short pings from meteor trails. These two modes are FSK441 and JT6M. JT6M is especially optimized for working meteor scatter on 6 meters, while FSK441 works well up into the higher VHF bands.

With either of these modes, the QSO exchange is much like other digital modes, where the communication is textual. WSJT is a high-duty-cycle mode, so you must ensure that you set up your equipment properly (don't overdrive your amp, keep an extra fan on the transceiver, etc.). Once you have everything set up for operation, announce yourself on one of the scheduling sites on the Internet. Two of these are <http://www.pingjockey.net/cgi-bin/pingtalk> and <http://dxworld.com/vhfsked.html>.

Most meteor schedules will run for 30 minutes, but they can be shorter or longer. You and the other operator must agree beforehand so that you are coordinated. Remember to follow the standard format, where the westernmost station transmits the call for the first 30 seconds while the other station listens. Then the other station transmits for the next 30 seconds. Each minute is broken in two parts, 30 seconds for each part. The station in the most western end of the path will transmit during the first 30-second period. The most eastern station takes the second period to transmit. This requires that both of you are set to the same time, exact to the second.

When it is your turn during the minute, you would transmit something like "KD7QKT NW7US KD7QKT NW7US KD7QKT NW7US." The idea is to keep things short and sweet. At least halfway into your 30-second period, you might break your transmission for a pause to see if there is a meteor burst that your schedule partner wants to take advantage of. A pause like this, of a second or two, gives the other station a chance to transmit data, if possible. Of course, you might pause a few times during each period.

What do you exchange? As with any mode of operation, you exchange callsigns, some type of information or report, and a confirmation of the same. When a station copies both calls, that operator sends calls and report. If both calls and a report are received, that station sends the report and a "Roger." When both get a pair of "Roger" (this might take several exchanges) the QSO is officially complete. However, the other station will not know this, so it is customary to then send "73" to let the other station know that it's complete, even though the "73" is not required for a complete QSO. Mobile, portable, and DXpedition stations normally never send 73 unless they are shutting down, but instead return to calling CQ immediately after the exchange of Rs. Full details are published at <http://www.qsl.net/w8wn/hscw/papers/hscw-sop.html>.

Can You Listen In?

It is possible for you to listen for meteor-scatter bursts. Some even hook up special software to graph the meteor-shower radio activity. If you would like to hear examples of meteor pings, visit <http://www.spaceweather.com/glossary/nasameteorradar.html>. Let's look at how you might listen in with your own radio.

One method is to tune an FM radio to a clear frequency that is also known to be the frequency of a radio station far beyond line-of-sight. You can also use other frequencies, if you know of a transmitter located hundreds of miles away, licensed on that frequency. The frequency range most suited to meteor scatter lies between 40 and 110 MHz. It is most effective to select stations that are north or south of you.

You can then listen and record each meteor burst, identified by the quick burst of radio signal on that frequency. If you are tuned to an FM station channel, and suddenly hear a burst of voice or music, you know that you are hearing that distant station via meteor scatter. Or, if you are tuned to a TV station, you might hear the buzz of the TV signal.

You might try hooking up your receiver to your computer to record the pings with software. Two very useful software tools used for this purpose are the Meteor DOS and Colorgramme. Visit <http://radio.meteor.free.fr/us/main.html> for details and download information. These are free specialized software programs use to detect and record radio-signal echoes produced by meteor-shower pings.

Finally, check out the Audio Gallery of Radiometeor Events at <http://www.amsmeteors.org/audio/index.html>. This

site offers actual recordings of radio energy created by the meteors as they burn up.

Other Meteor Showers of Summer

Look for the *Draconids,* a primarily periodic shower which produced spectacular, brief meteor storms twice in the last century, in 1933 and 1946. Most recently, in 2005, we saw the stream's parent comet, 21P/Giacobini-Zinner, returning to perihelion. This year's peak is expected to occur on October 8 at 1030 UTC. The shower should be active from October 6 through October 10. The *Draconids* meteors are exceptionally slow-moving, a characteristic that helps separate genuine shower meteors from sporadics accidentally lining up with the radiant. This is a good shower to work meteor-scatter mode, since we might see storm-level activity this year. For more information, take a look at <http://www. imo.net/calendar/2008>.

The Solar Cycle Pulse

The observed sunspot numbers for April and May 2008 both are 2.9. The smoothed sunspot counts for September, October, and November 2007 are 5.9, 6.1, and 5.7.

The monthly 10.7-cm (preliminary) numbers for April and May 2008 are 70.3 and 68.4. The smoothed 10.7-cm radio flux for September through November 2007 is 71.5, 71.5, and 71.1.

The smoothed planetary *A*-index (*Ap*) numbers for September through November 2007 are 7.8, 7.9, and 7.8. The monthly readings for April and May 2008 are 9 and 6.

The monthly smoothed sunspot numbers forecast for August through October 2008 are 7.4, 8.6, and 9.9. By this forecast, it looks like we are at the very beginning of the new solar Cycle 24.

The smoothed monthly 10.7 cm numbers are predicted to be 65.1, 65.4, and 66.1 for the same months. These numbersalso indicate that Cycle 24 is upon us.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E,* meteor scatter, etc.). I'll create summaries and share them with the readership.

Up-to-date propagation information can be found at my propagation center, <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing!

73 de Tomas, NW7US

By Miguel Enriquez, KD7RPP

Amateur Television for Fun and Education

Getting Yourself and Students Started in Amateur Television

When first exposed to Amateur Television (ATV), many students show immediate interest in the medium because it is something with which they grew up. Furthermore, to be able to see themselves on the television screen is an exciting proposition for them, as well. To know that the magic of television can be theirs to explore becomes a motivating factor in deciding to learn how to use it and eventually how it works. That is what is happening in our school radio shack where our ham radio club members have been enjoying ATV for over a year.

At first glance, ATV appears to be a difficult and expensive undertaking. However, the initial investment for the entire station can be less than $500. Furthermore, with some proper guidance from an Elmer who has been enjoying the use of ATV for a while, your first ATV station is not far away.

It is possible to get your station up and running while you are learning and developing the technical skills and knowledge for ATV. To do this, you will need to find an Elmer who can help you identify the necessary equipment and set up the station. If none is available, we can help you get the direction and support by way of our being your DX Elmers. Perhaps some of our students presently using ATV in the classroom can QSO with your students to answer their questions and share some of their experiences.

The costs of developing an ATV station can be kept to a minimum by looking around your shack for available materials and equipment. An old television (analog) is the first order of business. The ATV transmitter/receiver can be purchased from a couple of dealers who sell ATV equipment, or they can be found on the Internet as pre-owned equipment at several swap meet sites. An old video camera like the one you use to capture mem-

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This column was written with a great deal of assistance from Ronald Phillips, AE6QU.
e-mail: <sunsettelcom@juno.com>

Jhovana Peralta, Juan Puig, and Ruth Colores with Pueblo Magnet High School BOE-BOT #1.

ories at your family's picnics, etc., will work very nicely.

The students can have fun constructing "Cheap Yagi" antennas from blueprint instructions readily available on the Internet, as well as in *CQ VHF*'s "Antennas" columns by Kent Britain, WA5VJB. Low-loss cable is the one thing that becomes critically important in transmitting and receiving ATV signals, because any loss of signal strength degrades the quality of the picture and sound that is transmitted or received.

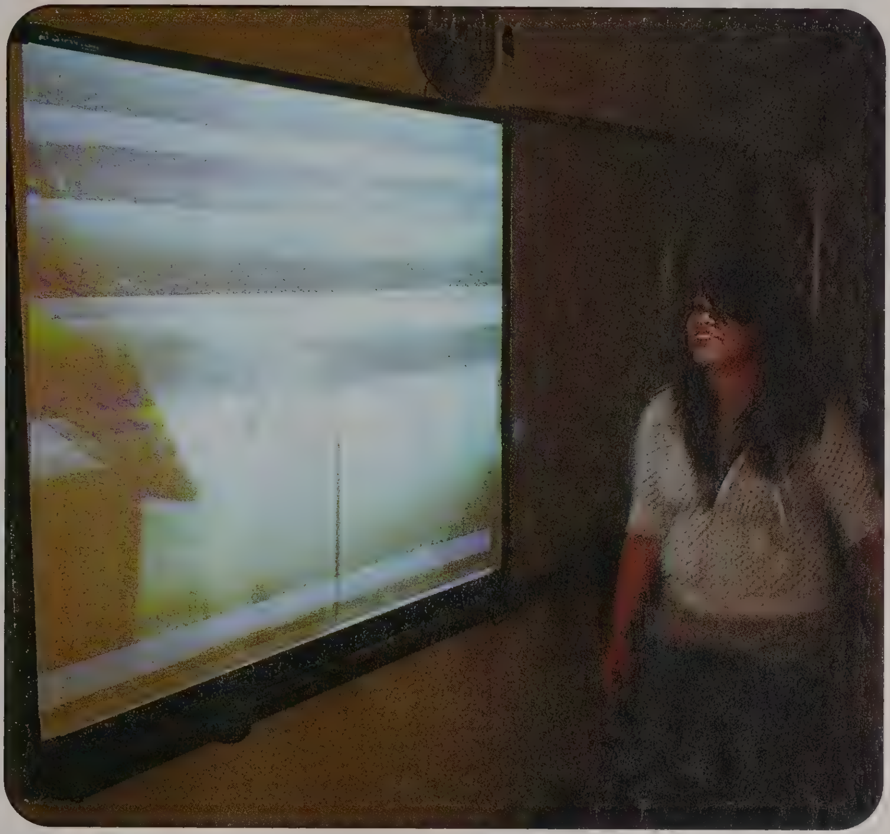
ATV equipment currently on the market, new or used, is designed for ease of use. After your station is set up and calibrated, little maintenance is required. The station can be set up in any corner of the classroom or ham shack, as it does not require much space or special lighting. As you learn to use ATV equipment, you and your students will easily be able to solve any challenges the technology presents.

Perhaps the biggest problem in using ATV is finding a second station with which to converse. Transmitting distances are a limiting factor in ATV. Unless you have a repeater high up on a mountain, like we do, you are limited to line-of-sight contacts. Furthermore, the other station must have a station that transmits and receives on the same frequencies as your station. Regrettably, this has been a major problem for our club. However, finding a second school in your area or a ham club willing to set up a station to communicate with students could be part of the challenge you accept when you commit to adding ATV to your school radio shack.

If finding a second school or ham willing to add an ATV station to their shack is impossible, you can still go at it alone. ATV is designed to be portable. This means your students can build two or more ATV stations and then they can still enjoy the fun the medium brings.

Your second ATV station can go to a local hamfest where the students can show off their ATV skills to other hams. They can go into another classroom or school or other public event and transmit to the school shack while the public walks by and watches, stopping to ask what is going on and then being impressed that the students are successfully delving into television transmissions.

Another possible use of ATV is in conjunction with robotics. Today many students are into robotics. Adding ATV to a robot and having it roam outside the classroom or into the school cafeteria while the students sitting in class see and hear the images the robot is transmitting is an exciting event. When our students added an ATV camera to the BOE BOT, used in class to learn about electronics and programming, and sent it out the door to transmit temperature, direction of travel, seismographic readings, as well as video and audio signals, you would have thought that even Harold Van Dyke, KD2PH, a fellow ATV ham who monitors ours signals and who was receiving the signal in Sun City, Arizona 135 miles away would get excited. However, the students watching these same signals 115 feet away were more excited because it was their ATV station at work!



Jasmine Magdaleno explains to the class the significance of the signal received from the "MARS LANDER" roaming 90 feet outside the classroom.

Summary

In summary, the journey to ATV can be as easy or as complicated as you perceive it to be and make it. We suggest you consider the possibilities that ATV can provide for students and look into adding ATV to your school or home ham shack. If your main concern is that by adding ATV to your shack others will see the mess most of us have surrounding our transceivers, you can point the camera in the opposite direction and no one will be the wiser!

Why go through all this trouble in designing, constructing, and running an ATV station? Negative comments can range from "It's expensive," to "I don't know anything about ATV," to "Why bother?" However, the one reason why you should consider ATV is simply because it is fun, and for students, it gives them an opportunity to feel good about accomplishing a task that is truly unique.

Many students tell us they want to be important and feel successful. We guarantee that when they are able to see themselves on television and communicate with other students using ATV they will know they have accomplished something important.

Please e-mail us with your questions or specific needs for direction or information concerning ATV. We will gladly work with you to identify resources close to you to assist you in this perhaps new and exciting addition to your shack.

Future columns will provide more specific information concerning ATV technology and where to go for equipment and information resources.

73, Miguel, KD7RPP

By Kent Britain,* WA5VJB

Connecting the Radio to the Sky

ATV Antennas plus Antenna Ranges

This issue of *CQ VHF* covers several ATV (Amateur Television) topics, so it's a good time to update and revisit a pair of ATV antennas for 915 MHz (one 6-element and one 10-element) and one for 2.4 GHz. We will also go over an interesting myth about antenna ranges.

Quite a few ATV systems use 915-MHz FM video input, and for low-power video systems 2.4 GHz is the favorite band. Therefore, in this column we will cover both a 915-MHz Yagi and a 2.4-GHz patch antenna. But keep this quiet: These antennas also work well for digital, FM, SSB, 802-11, and other 900-MHz/2400-MHz services.

915-MHz Antennas

We start with a 915-MHz version of the "Cheap Yagi" shown in photo A and figure 1. The boom can be any non-conductive material. Yes, PVC pipe can be used, but I find that a good hard wood about 1/2 to 3/4 inch in width is stronger and seems to last longer, especially if you give it a coat of paint. All elements are 1/8 inch in diameter. I have used ground-rod wire, #10 and #12 electrical household wire, welding rod, and hobby tubing from the model-airplane shop. Again, almost any 1/8-inch diameter metallic material can be used for the elements. However, for the driven element it is good to use copper or brass so that you can directly solder the 50-ohm coax to the driven element. Small clips have been used to clamp the wire to the driven element, and these can be fun to make, but often they corrode quickly when mounted outside.

The same driven element shown in figure 1 is used for both the 6-element and 10-element versions of the 915-MHz Yagi (see Table 1).

Patch Antenna for 2.4 GHz

Next we have an easy-to-make patch antenna for 2.4 GHz, shown in photo B.

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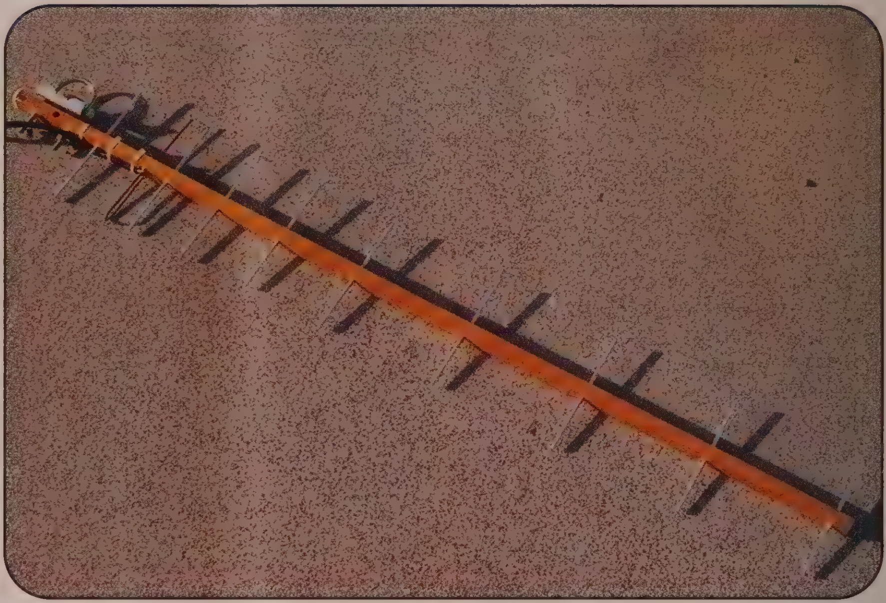


Photo A. Cheap Yagi for 915-MHz ATV.

This antenna works well with the various 2.4-GHz video senders, Bluetooth®, and other wireless products. For AMSAT it can be used to listen for many of the stronger transponders, or placed at the focus of a small dish for even more gain. Gain is in the 8- to 9-dBi range, and the antenna easily has over 200 MHz of bandwidth.

Construction is simple. The back plane can be almost any sheet of metal. Of course, aluminum is easy to find, and in this case I used some old PC board. For

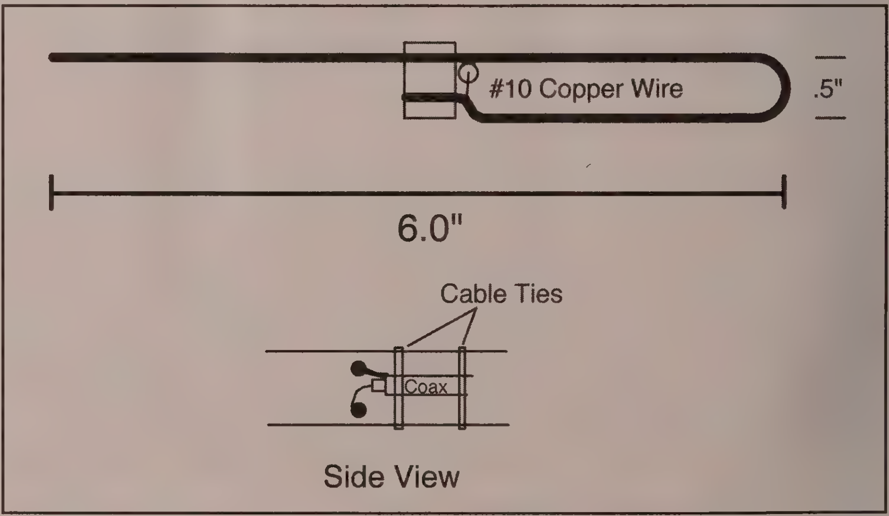


Figure 1. Dimension for the 915-MHz driven element.

	R	DE	D1	D2	D3	D4	D5	D6	D7	D8
6 Elements										
Length	6.3	**	5.7	5.6	5.5	5.2	—	—	—	—
Spacing	0	2.4	3.5	5.0	8.25	11.5	—	—	—	—
Gain 11 dBi										
F/B 22 dB										
10 Elements										
Length	6.3	**	5.7	5.6	5.5	5.3	5.3	5.3	5.3	5.0
Spacing	0	2.4	3.5	5.0	8.25	11.5	15.0	18.0	21.1	24.25
Gain 13.5 dBi										
F/B 25 dB										

*** Driven element (see figure 1)*
R—Reflector
D#—Director
F/B—Front-to-back ratio for the antenna pattern

Table 1. Specifications for the 6-element and 10-element 915-MHz Cheap Yagi.

the patch element you want to use something that is easy to solder. Sheet brass, sheet tin, sheet copper, or another piece of PC board work well. Just build per the dimensions in figure 2 and go. If you need to make your patch more rugged, note that the very center of the patch is a null point. You can drill a hole in the middle of the patch and support the patch on a long bolt line as shown in the patch in photo C.

Antenna-Range Mistakes

"But I put both antennas in the same spot!" I heard one antenna tester say that because he puts the reference antenna and the test antenna in exactly the same spot, then his gain numbers are perfect.

Not exactly. This is only true when both the reference and the test antenna are identical. In the real world, using the same spot without making sure the test area has a uniform signal strength can result in some pretty big errors. The problem is that when you have two antennas with different gain, then they also have different capture areas, or aperture areas. The test signal must be uniform over the aperture area of the larger of the two antennas. (See figure 3.)

In figure 4 we have a typical pattern for a source antenna on an antenna range when the source antenna is mounted several wavelengths off the ground (also see figure 5 for a typical pattern of the source antenna when mounted low). Note all the peaks and nulls in the test area.

I wish my CAD package would do a better parabola, but you get the idea. If you just happen to put the reference antenna in a null and the antenna you are testing just happens to have a larger capture area, then the apparent gain of the antenna being tested can come out up to 3 dB high. If you twist the antenna being tested a little up and down, then you can get the top and bottom lobes back in phase. Now the apparent gain jumps up even higher. Put in simple terms, if a 10-dBi reference antenna is used to test a 20-dBi antenna, the results if the reference antenna is in a null can be 23 dB or more. (See figures 6 and 7.)

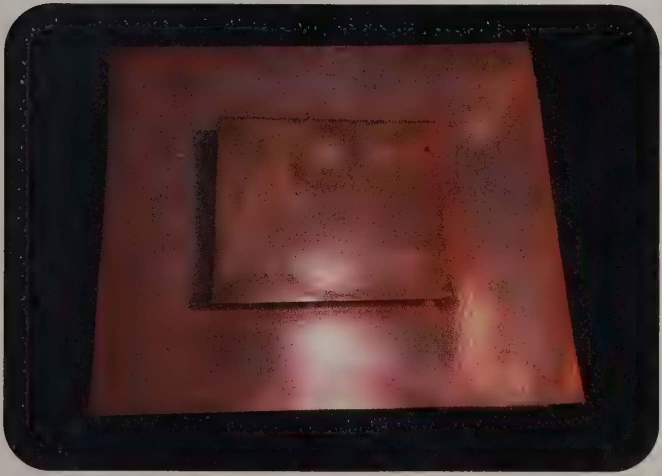


Photo B. The 2.4-GHz patch antenna.

Photo C. A version of the patch antenna with a center bolt for better mounting.

Now let's go the other way. You have a large reference antenna and a smaller antenna being tested. The big one is catching some signal and the little one is not/ Now gain can be underestimated at 7 to 8 dB, and your 10-dBi antenna measures 2 or 3 dBi.

Now let's look at when the reference antenna is perfectly in the major signal lobe but the antenna being tested has a larger capture or aperture area. The test area is a three-dimensional

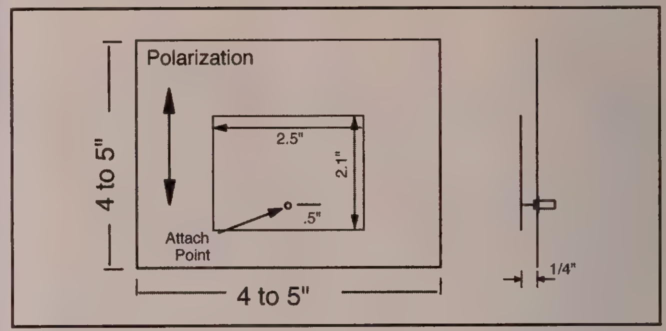


Figure 2. Dimensions for the 2.4-GHz patch antenna.

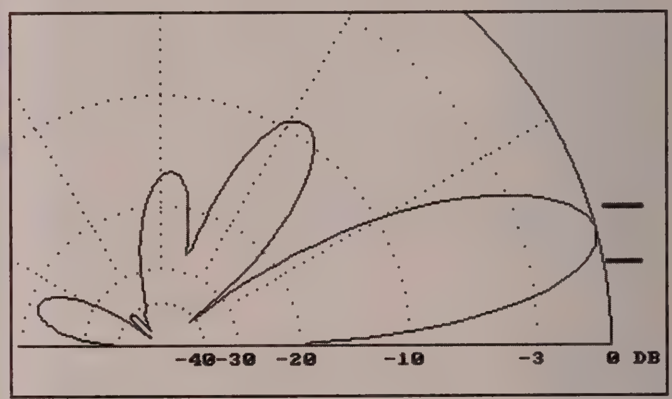


Figure 3. Antenna testing with a low source antenna and a more uniform test area.

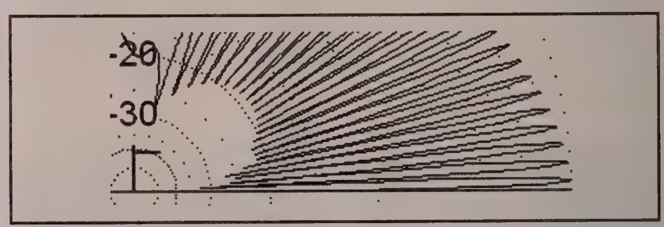


Figure 4. Typical pattern of the source antenna when mounted high.

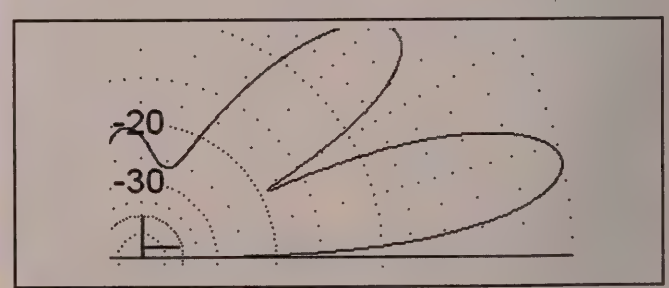


Figure 5, Typical pattern of the source antenna when mounted low.

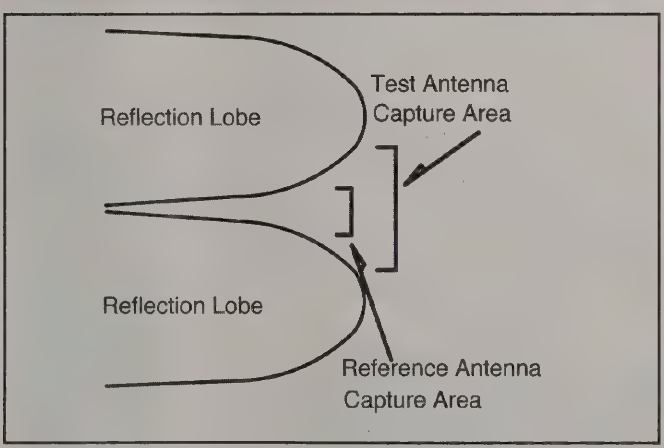
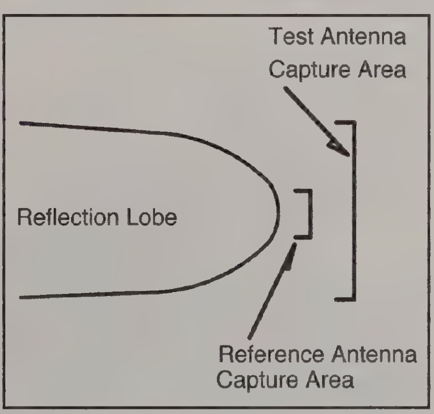


Figure 6. Antenna testing in a ground bounce null.

Figure 7. Antenna testing in a ground bounce peak.



volume that has been simplified for these examples. Even the conductivity of the ground can change the depth of the nulls, but these error values are what you would see in a poor range setup.

In short, simply using an antenna range without making sure your test area has a nice, uniform signal strength can really misrepresent the actual gain of the antenna. Most errors make the test antenna look worse. Errors can make the antenna test show as much a 3 dB better than it is, or as bad as 8 dB worse than it really is. The 11 dB of measurement error makes the test results more a list of random numbers than meaningful antenna measurements.

Using the same antenna-range geometry on several frequencies without knowing that the test area has a uniform signal does not produce accurate results.

When you set up an antenna test range you have to sample the area. Move your reference antenna up, down, left, and right. If the signal strength varies more than a dB, find another test area, change the range geometry, but do something or your results are meaningless.

As always, our readers are one of the best sources of ideas for future antenna projects. Any antenna questions, or antenna projects you would like to see, just drop an e-mail to <wa5vjb@cq-vhf.com>, or visit <www.wa5vjb.com> for additional antenna projects.

73, Kent, WA5VJB

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Back to the Present

In the Spring 2008 issue of *CQ VHF* we reviewed the history of AMSAT. In this issue we will talk about where we are today in satellite availability, equipment ideas, and operating techniques. I will lean on experiences at this year's Dayton Hamvention®, Ham-Com, and ARRL Field Day 2008.

ID	Frequencies (Uplink/Downlink)	Modulation Modes
AO-07	U/V, V/HF	SSB and CW
AO-27	V/U	FM Voice
GO-32	V/U	FM Packet
SO-50	V/U	FM Voice
AO-51	V/U, V/S, L/U, L/S	FM, FM Packet, SSB/CW, etc.
ISS	V/V, U/V	FM Voice, FM Packet
VO-52	U/V	SSB and CW

Table 1. The "birds" that have active transponders support the frequencies and modes listed above.

Satellite Availability

Today we have a real mixture of the "old and the new." We regularly use our oldest operational satellite, AO-07, and we listen to the seven new CubeSats (Cute-1.7, SEEDS, Delfi-C3, AAUSat-II, COMPASS-1, CanX-2, and CanX-6) and RS-30, Yubileiny. AO-07 was launched in 1974. The CubeSats were launched in April 2008, and RS-30 was launched in May 2008. Between these extremes we have AO-27, GO-32, SO-50, AO-51, the ISS, and VO-52, all of which still have active transponders.

Earlier this year one of the original Microsats, AO-16, was given a change in mission and was active for several months while it was in an eclipse-free period. It apparently has a temperature problem that has shown up now that it is undergoing eclipses again. Hopefully, we will see more use of it when it becomes eclipse-free again. It is also possible that we may be able to do the same "trick" on one or more of the other old Microsats and see some more use out of them.

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Cheap circularly polarized L-band Yagis with white box full of up-converter and amps. Note the expensive rain cover on the white box.

The "birds" that have active transponders support the frequencies and modes listed in Table 1.

AO-51 continues to be a real "hoot" to work with its good signals and variety of modes and capabilities. At Ham-Com in Plano, Texas in June, it was in V/S and on Field Day 2008 it was in V/U and L/U simultaneously.

Complete details on these "birds" are available on the AMSAT web page: <http://www.amsat.org>. Details on the CubeSats are available on Ralph Wallio's (WØRPK) web page: <http://showcase.netins.net/web/wallio/CubeSat.htm>. Details on RS-30 are still somewhat "sketchy."

Dayton Hamvention®

AMSAT had an expanded presence at Dayton this year. An additional booth space was devoted to demonstrations and live discussions of the current AMSAT projects. Engineering team leaders of all of the projects were available for questions and discussions. Featured projects were: Eagle, Advanced Communications Package (ACP), ACP Ground Segment, SuitSat 2, and Phase 3E. ACP is planned to be a common payload for both the AMSAT Eagle and Intelsat Phase IV Ride Share projects.

Team Namaste, including both ACP and ACP Ground Segment, was introduced at Dayton. ACP is under the leadership of Matt, N2MJI, and the ACP Ground Segment is led by Michelle, W5NYV. This exciting new capability generated great interest. In particular, the Ground Segment is being planned as an affordable, transportable, microwave digital communications package that will be within the capabilities of the average ham to assemble and operate. Details are available at: <http://www.amsat.org/namaste>.

A working Software Defined Transponder (SDX) for SuitSat 2 was demonstrated at Dayton, along with other plans for SuitSat 2.

Presentations were given during the Saturday morning AMSAT Forum on all of these projects, along witha report on AMSAT's general status and updates on AO-51 and AO-16 activity.

Finally, yours truly along with Mark Hammond, N8MH, and Roger Ley, WA9PZL, did the outdoor live satellite demos. This year we featured the simple Cheap LEO Antennas designed by Kent Britain, WA5VJB, and the Manual Positioner designed by me. All of this hardware was described in past issues of *CQ VHF*. All demos were done with either one or two Yaesu FT-817s running barefoot at 5 watts. We were able to do live demos on all three days through AO-51, AO-27, AO-07, and VO-52. For unknown reasons, we did not make it through SO-50. Mark succeeded in commanding AO-16 back on twice from the demo area, but it did not stay on due to the suspected temperature problem mentioned previously. We also communicated from the outdoor demo area through the SuitSat 2 SDX at the AMSAT booth inside the arena.

Ham-Com

Ham-Com was held only a couple of weeks after Dayton in Plano, Texas. For those who are geographically challenged, Plano is a northern suburb of "Big D" (Dallas). The AMSAT booth, forums, and demos were on a smaller scale than those at Dayton, but AO-51 was in mode V/S during Ham-Com. This gave us the possibility of demonstrating communications through AO-51 with a Cheap LEO Antenna fed by a Kenwood TH-D7 and received by a hand-held K5GNA S-band down converter and antenna into one of the FT-817s as a 2-meter IF. We were able to make excellent AO-51 V/S demos on both days of Ham-Com. Demos on all of the other "birds" were accomplished with the same setups used at Dayton.

ARRL Field Day 2008

Last year at this time I featured my Field Day station setup using two FT-817s, SatPC32, Yaesu rotors, and Hy-Gain satellite antennas, along with a homebrew helical antenna for L-band. I bring this up again because of a change in the L-band antennas used for AO-51 mode L/U operations. This year I used a pair of WA5VJB Cheap Yagis on L-band instead of the WD4FAB helical antenna. These were fed as a circularly polarized pair in accordance with Kent's article in the Fall 2003 issue of *CQ VHF*. Actually, I borrowed from Kent's the prototype antennas for the article and provided the first real "on the satellite test" of these antennas. The setup is shown in the accompanying photos. Once again, the white plastic box contains the L-band up-converter and power amps.

We actually made it through the "bird" without the final power amp keyed. When our mistake was discovered and corrected, the signal was stronger, but the fact remains that we made it through the "bird" with about 10 watts of power instead of the planned 25 watts.

Satellite Field Day went well considering the fact that a thunderstorm gust front took down our meager shelter just after the first evening AO-27 pass and before the evening flock of "birds"

Feed details for L-band Yagis. Note that Yagis are rotated 90 degrees with respect to one another, and one is spaced a quarter wavelength down the boom from the other. The power splitter is made from two equal lengths (each an odd multiple of a quarter wavelength long) of 72-ohm coax.

came over. We had to scramble to place the rigs, computer, etc., in my mini van for protection from the rain that followed. We literally "blew off" the evening passes and again set up everything for the Sunday morning passes. We actually made it through all of the FM "birds" for our allotted one contact each. The remainder of our contacts were made on AO-07 and VO-52 SSB.

Here's one more Satellite Field Day "word to the wise." We were barely able to get through AO-27, SO-50, and AO-51 V/U FM with about 40 watts and a 16-element, computer-steered Hy-Gain antenna. It took patience and perseverance to make it. A good part of the time all we could hear was the noise level created by hundreds of signals getting to the satellite at about the same strength. Eventually, someone would exceed the threshold and a contact was made. Compare that with the Dayton and Ham-Com demos, where all contacts were made relatively easily with a 2- or 3-element Cheap LEO Antenna and 5 watts. The FM "capture effect" is alive and well.

Summary

This column is intended to illustrate the variety of satellite communications that is available today and the current projects planned for the future. In particular, it is meant to emphasize the "cheap and easy" concept of working satellites.

Don't forget to support AMSAT in its education and fund-raising efforts so that we can continue to put more "birds" on the air. In particular, support Phase IIIE, Eagle, and the Intelsat Phase IV Ride Share projects so that we can get back into the HEO (High Earth Orbit) satellite business. 'Til next time . . .

73, Keith, W5IU

CQ's 6 Meter and Satellite WAZ Awards

(As of July 1, 2008)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,2,12,18,19,32

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>*

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

National Science Education Standards

You may have read in recent issues of the *AMSAT Journal* about plans to develop an AMSAT Teacher's Institute to provide educators with the background necessary to incorporate satellites into their curricula. This column summarizes the standards with which such an effort must comply.

The fundamental law governing education throughout the U.S. is No Child Left Behind (NCLB, which is pronounced "nickelbee" by educators). NCLB mandates achievement testing for all students in the areas of reading and mathematics, and ties federal funding for school districts not to test results *per se*, but rather to *improvement* in test results from year to year. In other words, the goal of NCLB is to show annual progress. Most school districts set achieving NCLB guidelines as their highest priority. At present, there are no accepted standardized achievement tests in the sciences, and hence no NCLB science standards. Most educators with whom I've spoken expect NCLB science standards to be established eventually, but this is not likely to happen for a decade or more. Hence, professional development in the sciences is not currently a priority for educators or school districts.

National Science Education Standards do exist, but compliance is strictly voluntary on the part of individual school districts. These standards were developed jointly by the National Science Teacher's Association (NSTA), American Academy for the Advancement of Science (AAAS), National Science Resources Center (NSRC), National Research Council (NRC) National Science Foundation (NSF), and several smaller organizations, working through the National Committee on Science Education Standards and Assessment (NCSESA). The standards emphasize benchmarks for science literacy and were distributed in draft form in 1994 to 18,000 individuals and 250 groups.

The goals for school science that underlie the National Science Education Standards are to educate students who are able to:

• experience the richness and excitement of knowing about and understanding the natural world;

• use appropriate scientific processes and principles in making personal decisions;

• engage intelligently in public discourse and debate about matters of scientific and technological concern; and

• increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.

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Logically, any AMSAT educational endeavor should show compliance with these four points.

The National Science Education Standards address continuing education and professional development requirements for teachers. The standards address various professional development areas, which can be summarized as: learning science, learning to teach science, and learning to learn. Specific standards in these areas are excerpted below.

Standard A

Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. Science learning experiences for teachers must:

• Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.

• Address issues, events, problems, or topics significant in science and of interest to participants.

• Introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.

• Build on the teacher's current science understanding, ability, and attitudes.

• Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.

• Encourage and support teachers in efforts to collaborate.

To meet the standards, all teachers of science must have a strong, broad base of scientific knowledge extensive enough for them to:

• Understand the nature of scientific inquiry, its central role in science, and how to use the skills and processes of scientific inquiry.

• Understand the fundamental facts and concepts in major science disciplines.

• Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects.

• Use scientific understanding and ability when dealing with personal and societal issues.

Standard B

Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching. Learning experiences for teachers of science must:

• Connect and integrate all pertinent aspects of science and science education.

• Occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.

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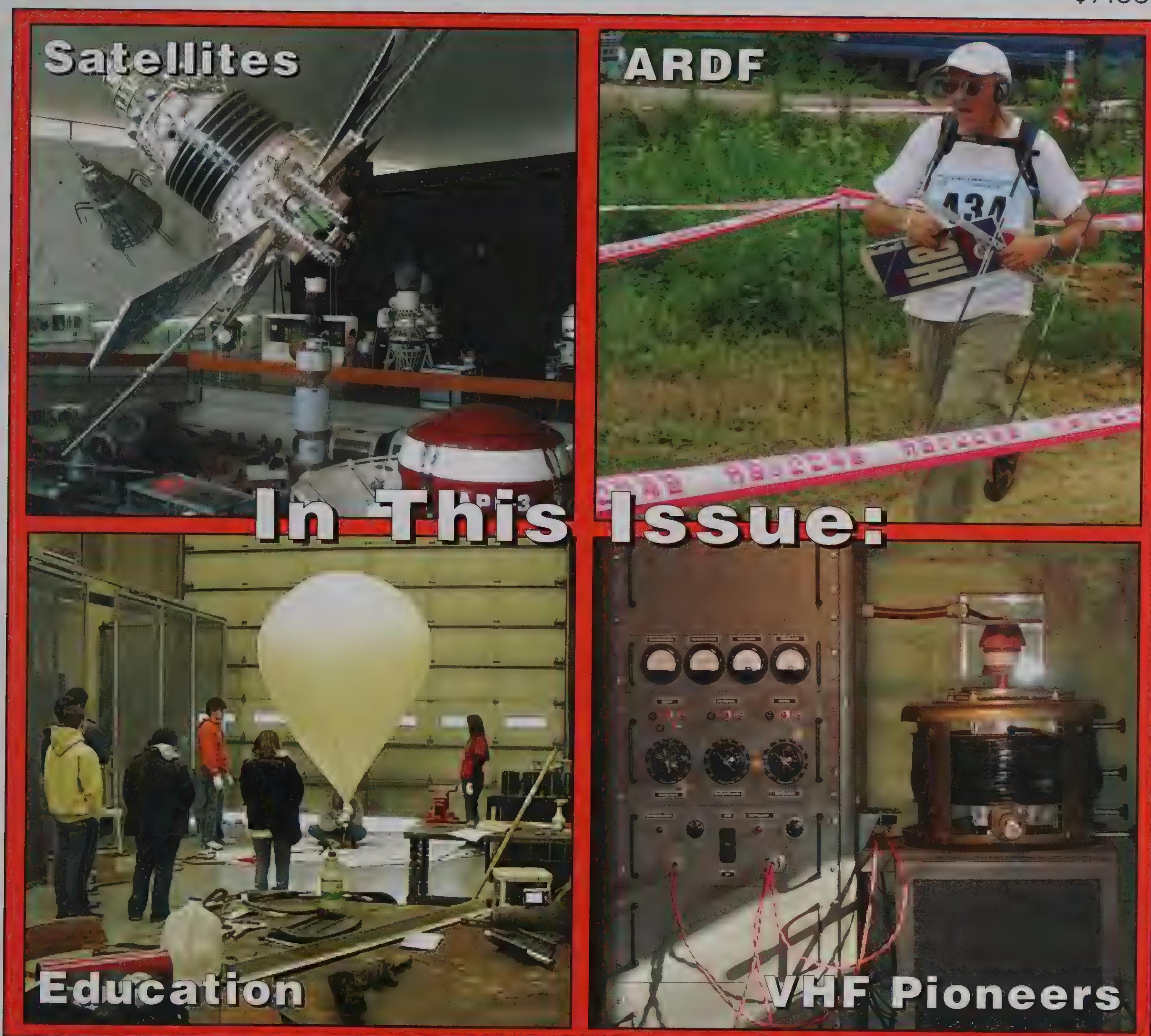

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CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

The 2008 TAPR/DCC Conference

In all my years of attending conferences, I have never seen such a well-organized event as this year's TAPR/DCC conference. Three factors contributed to the success of the conference. First was the leadership provided by TAPR president David Toth, VE3GYQ, and TAPR vice-president Steve Bible, N7HPR. They saw to it that all of the oversight details were handled well.

Next was the on-the-ground leadership of Kermit Carlson, W9XA, and Mark Thompson, WB9QZB. Kermit and his crew were responsible for making sure everything worked properly at the venue, the Chicago Holiday Inn hotel. Among their responsibilities were making arrangements at the hotel, setting up and operating the audio/visual equipment. The A/V equipment was provided by Ron Steinberg, K9IKZ, of RC Communications (more about his part appears below). Mark was responsible for working with local clubs and the local publicity for the conference. Both Kermit and Mark were recognized for their hard work during the banquet (see photo).

Finally, as mentioned above, Ron Steinberg, K9IKZ, was responsible for the A/V—and superb is the best way to describe his setup. Two large screens with flame-thrower projectors were positioned on opposite sides of the stage area in the main ballroom. In addition, two remote, large-screen LCD monitors and speakers were installed in the hallway and the demo room, which allowed participants in those areas to keep track of presentations.

As part of the A/V presentation, during breaks a rotating PowerPoint slide presentation was projected and featured each of the significant supporters of the conference. Because *CQ VHF* was a sponsor, I was quite pleased to see our logo as part of that rotation.

All of this superb organization provided the setting for the excellent presentations that were made throughout the weekend. Thanks to Gary Pearce, KN4AQ, a DVD of each of the presentations will be available for purchase in about three months. Watch for an announcement of its availability in my "VHF Plus" column in *CQ* magazine.

On a personal note, I would like to say thank you to all concerned for their very gracious hosting of my wife, Carol, W6CL, and me during our all-too-brief stay at the conference. Because of my church commitment on Sunday morning, we had to fly back on Saturday evening. Even so, the hospitality shown by all to us during our stay was deeply appreciated.

Next Year's Conference

The leadership has agreed to hold the conference in Chicago at the same hotel in 2009.

The TAPR/DCC banquet recognized some of those who contributed to the success of the event (left W9XA, right WB9QZB).

A strong factor in this decision was the use of the excellent A/V equipment this year, which Ron agreed to make available again next year. What helped make it possible to use the A/V equipment for the TAPR/DCC conference was that it had been used for the W9DXCC convention the prior week. In discussing the A/V availability with me, Ron commented that it made economic sense to keep everything in place for both events.

A New Way of Hosting Ham Radio Events?

Ron added that what would make even more economic sense in these times of belt-tightening was for ham radio organizations to plan back-to-back-to-back events. He suggested that next year the W9DXCC convention could be followed by a midweek event organized by an antique radio organization, which would then be followed by the weekend TAPR/DCC event. The benefits could be a possible hotel package for some who would want to take in all three events, plus some sort of discount price that could be negotiated for all three events. Also, having the same A/V equipment in place for the whole week would be much less costly than installing and then tearing down after each event. A final benefit would be the cross-pollination of the hams attending each others' events. Hams attending one event could learn about what other hams are doing and maybe get some new ideas for their own niches in the hobby.

Ron concluded his conversation with me by suggesting that I consider promoting his idea of multiple events being held consecutively during a particular week. Perhaps other organizers could follow Ron's suggestion in other parts of the country. For example, a QCWA chapter could piggy-back on a regional hamfest to draw hams to both events.

Growing Use of Technology

Certainly, the A/V equipment used by both the W9DXCC and TAPR/DCC organizations raised the bar for future events. Several of the attendees with whom I spoke at the TAPR/DCC said that they had never experienced such quality in A/V production. With the bar set so high, what could be next?

In a conversation I had with Kermit Carlson, W9XA, about that subject, he informed me that as the president of the Central States VHF Society, he hopes to be able to present online video streaming of the conference at next year's event, which will also be held at the Chicago Holiday Inn. By making the video streaming available, he plans to also offer online registration for the event so that hams who are not able to travel to Chicago will also be able to participate in the conference. He added that the online arrangements would include a talkback feature so that online participants would be able to ask questions of the presenters.

In making next year's CSVHFS conference available online, Kermit is borrowing from the growing interest in online and distance education. For a variety of reasons, people are not able to travel to central locations to take courses. The answer to this dilemma is the use of the evolving internet technology to make it possible for students to receive comparable education at their distant locations.

A collateral benefit for what Gary Pearce, KN4AQ, and Kermit are doing (Gary with his DVDs and Kermit with his online access) is the archiving of the presentations that were made at the events. By way of Gary's DVDs and the subsequent downloading of the videos from the CSVHFS conference, hams will have access to technical presentation in ways that never before have been available. Both local hams and hams in far-away DX locations will be able to gain knowledge and insight from the presentations made during what had previously been isolated conferences.

It could very well be that along with setting the bar for future A/V commitment to a conference, the TAPR/DCC conference may have also provided the germination point for the future of knowledge transfer and cross-pollination for the Amateur Radio Service.

Until the next issue… 73 de Joe, N6CL

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Long-Range Summer 6-Meter Paths Between The U.S. and Japan

The "Magic Band" is full of mysterious propagation modes. Here WB2AMU comments on the Short-path Summer Solstice Propagation (SSSP) theory put forth by JE1BMJ.

By Ken Neubeck,* WB2AMU

During this past summer there were a number of interesting occurrences on 6 meters, particularly in the area of long-distance contacts being made, not only with the East Coast of the U.S. into Europe, but also to Japan into various parts of the U.S. during the months of June and July! This latter path has been the topic of intense discussion by many 6-meter operators regarding what the actual propagation modes are that cause dthis to occur.

In my previous article entitled "Observing the Double-Hop Sporadic-*E* Phenomenon on 6 meters," which was published in the Summer 2008 issue of *CQ VHF*, I discussed the occurrence of double-hop sporadic-*E* during the summer months. Typically, the presence of certain multiple-hop sporadic-*E* paths has allowed for the eastern part of the U.S. to work into western Europe (e.g., Spain, Portugal, and the Azores). This path was observed regularly this past summer.

Also during this summer there were several days when high-power stations in Japan were able to work many stations in the U.S. running high and sometimes moderate power. A number of 6-meter aficionados have started using the phrase Short-path Summer Solstice Propagation (SSSP) to describe this path in lieu of the traditional multiple-hop Sporadic-E model. (For more information on SSSP, see the article by Han Higasa, JE1BMJ, elsewhere in this issue.) The introduction of this model has created a bit of controversy and a lot of thought-provoking ideas. However, because of the near-regular occurrences of the U.S. to Japan path on 50 MHz this summer, something besides the traditional multiple-hop sporadic-*E* model may be needed to explain what has been happening.

This article will examine both the SSSP model, the traditional multiple-hop model, and the feasibility of each. As this is a phenomenon that is relatively new, there has been a lot of speculation involving initial observations, and hopefully through careful study this subject can be addressed properly.

History of Japan to U.S. 50-MHz QSOs

Over the years there have been a number of contacts between Japan and the West Coast of the U.S. that have been recorded on 6 meters, both via the *F2* mode during the high solar activity years and via multiple sporadic-*E* hops during the summer months. However, contacts between Japan and non-West Coast parts of the U.S. during the summer have been happening more often on 6 meters because of increased activity on the band, particularly with the appearance of high-power Japanese 6-meter stations.

Some of the contacts made between the U.S. and Japan on 6 meters during the latter part of the last century were documented in a paper by Jon Jones, NØJK, entitled "Multi-hop 50 MHz Sporadic-*E* Transpacific Propagation" which was presented in the *Proceedings* of the 27th Conference of the Central States VHF Society (1993).

In his paper, Jon discusses a contact that was made by WBØDRL in Kansas with JR3HED during the June 1992 ARRL

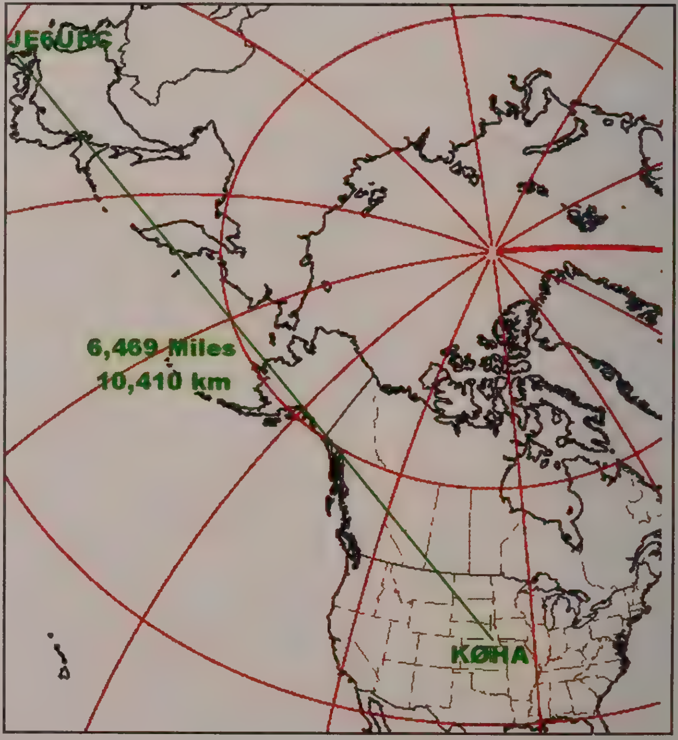

Figure 1. Plot of 50-MHz QSO between KØHA in Kansas and JE6URG in Japan. (Graph courtesy of Bill Hohnstein, KØHA.) The plot, constructed by Bill Hohnstein, KØHA, is of the 6-meter path between his QTH in Kansas and JA6URG, located in southern Japan, during the summer of 2008.

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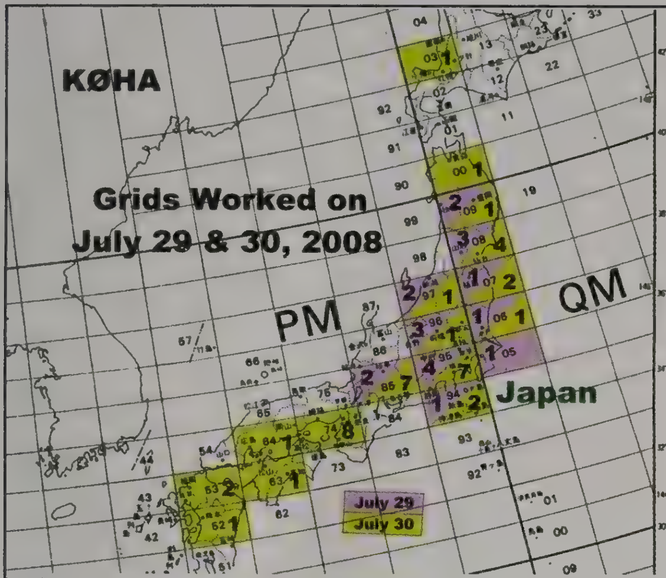

*Figure 2. Grids worked by KØHA on July 29 and July 30, 2008. (Graph courtesy of Bill Hohnstein, KØHA.) The figure shows a total of 17 different grids worked by KØHA over a two-day period. The timing of this opening would seem to fall out of the time frame of an SSSP-based propagation model and would seem to reflect a multiple-hop sporadic-*E *formation.*

VHF Contest at 0600 UTC on the Saturday of the contest. It took many calls and repeats for the contact to be completed. It was speculated that this was at least a five-hop sporadic-*E* event using a conventional model to explain this path. Jon also notes in his article that there were previous events that had been observed some years before 1993 during the summer months that involved other stations in the Midwest and Japan!

This path was experienced many times during the summer of 2008. One station that had excellent success is that of Bill Hohnstein, KØHA, with a typical 6-meter QSO taking the path that is shown in figure 1. Bill also worked many different grids in Japan during the two-day period of July 29th and 30th, as shown in figure 2.

The conditions for such a path to occur would require the station in Kansas or a surrounding area to point its directional antenna towards the northwest (roughly in the 300- to 320-degree direction from Kansas), while the Japanese station would point northeast (at 120 to 130 degrees). Signals for this path would generally be weak. Therefore, multi-element arrays of five or more elements seem to be the rule and usually with significant levels of power. It would seem that a different path was observed between California and Japan, as there would be a more pronounced polar crossing involved based on the direction of the antennas.

Multiple-Hop Sporadic-*E* Model

One point concerning the feasibility of a five-hop sporadic-*E* event occurring on 6 meters centers on the statistical probability of such an event. Figure 3 shows what this basic multiple-hop sporadic-*E* model for a contact between Kansas and Japan would look like. It is noted that two- and three-hop events are occasionally observed on 6 meters during the peak of the sporadic-*E* season, which usually occurs during June and July for many stations in the U.S. These peak months often favor directions such as the East Coast U.S. and parts of Europe.

However, while two- or three-hop propagation occasionally is observed, rarely have four-hop or five-hop events. Thus, it is safe to say that those events are rare, especially on a daily basis between the East Coast into areas past western Europe, such as eastern Europe and the Middle East.

Examining the geometry involved for stations in Florida to work into Japan by multiple-hop sporadic-*E* on 6 meters sug-

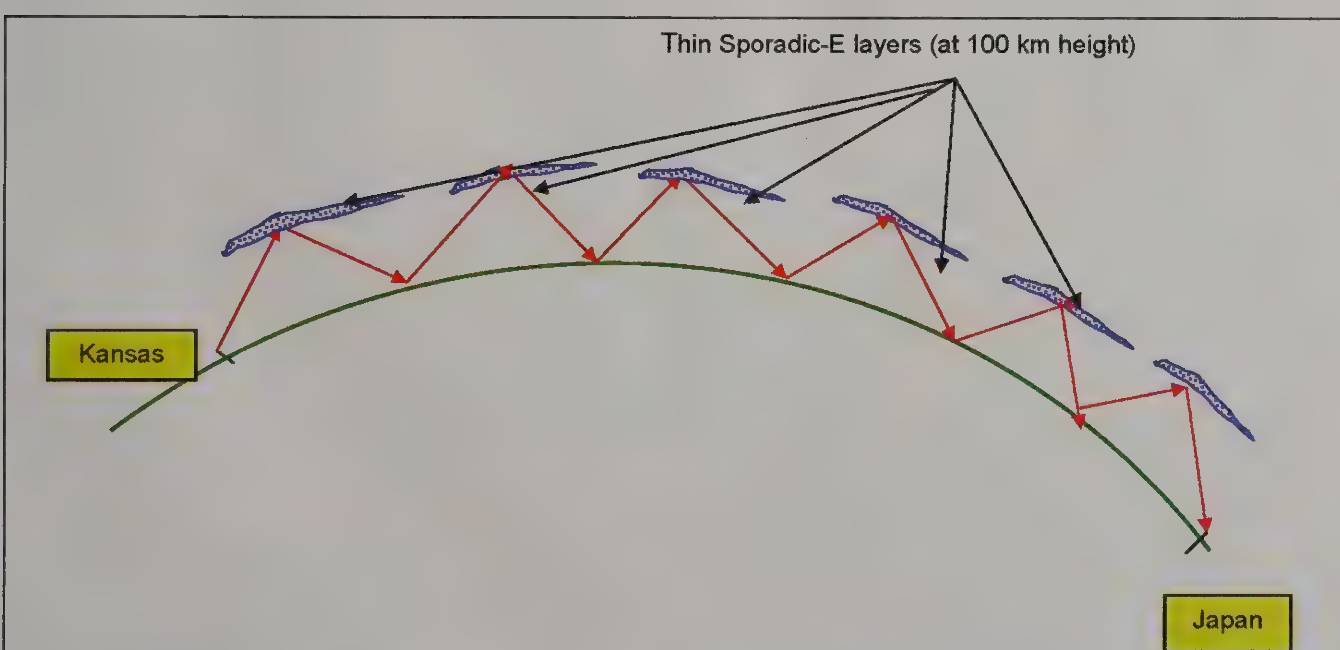

*Figure 3. Multiple-hop sporadic-*E *model for a 50-MHz QSO between Kansas and Japan.*

gests a minimum of six sporadic-*E* formations be involved using a conventional model as shown in figure 3. However, based on many years of observations, it seems odd that there would be several days of multiple-hop sporadic-*E* on the same path and not anywhere else. For example, it is hard to find multiple-hop sporadic-*E* events of long distance between the U.S. and other faraway locations in the Northern Hemisphere during the summer months, let alone observe them for a few days in a row! Thus, it would appear on the surface that there is something unique about the 50-MHz path between the U.S. and Japan that does not seem to be replicated anywhere else.

There are some favorable factors involved in the possibility of a consistent multi-hop sporadic-*E* path between Japan and the U.S. Measured as early as the International Geophysical Year (IGY) 1957–1958, Japan and the surrounding areas in Asia have been observed to have the highest incidence of sporadic-*E* of any location on the planet during the summer. Therefore, it is reasonable to conclude that multi-hop sporadic-*E* between Japan and other areas such as the U.S. has a realistic chance of occurring, in part because of the high amount of sporadic-*E* activity in the vicinity of Japan.

Now fast forward to the year 2008. This summer there were a significant number of observations on 6 meters between Japan and the U.S., particularly during the days before, on, and after the Summer Solstice. These events usually occurred around the same time period of 0000 to 0200 UTC, where it is the early evening hours in the eastern U.S. and early morning in Japan. One example is provided by the log of Dick Peacock, W2GFF, which shows a number of QSOs during this time between his station in southern Alabama and Japan. Using CW, he worked JE1BMJ on July 9, JHØRNN and JA7QVI on July 10, and JE1BMJ again on July 12. RST signal reports on his end ranged from 539 to 579. It seems truly amazing that this path occurred for three days in a four-day period in early July!

Incidentally, Bob Mobile, K1SIX, has collected several JA to U.S. observations from different stations during 2008 into one database at this internet location: <http://k1six.com/SSSP%20EVENTS%202008.pdf>. In reviewing his data, one can see a period of eight days in June and July when Japan was either heard or worked by stations located in the Midwest and southern U.S. (in particular, Florida, Alabama. and Texas).

With these many days of occurrences between stations in the U.S. and Japan during this time period, and based on observations in other directions, there is speculation that it seems highly unlikely that the mechanism was purely sporadic-*E* in nature, particularly since the path was going over the northern polar region. Indeed, past observations involving auroral-*E,* or Au*Es,* show that those long-range contacts can occur during the summer months, and it would not be impossible that this type of phenomenon could be involved in the path between the U.S. and Japan.

It appears that there are some unique long-distance paths on 6 meters that are repeated each summer season, The transatlantic path between the eastern U.S. and the coastal areas of western Europe generally can show up as a regular double-hop sporadic-*E* path that takes place between May and August, as discussed in my above-mentioned article in the Summer 2008 issue of *CQ VHF*.

This year I observed approximately ten such openings between May and August, with the grand finale for this path occurring on August 1, when I was able to work six different countries in the same general area of southern Europe and northern Africa on 6 meters CW during the early evening hours: the Azores, Spain, Portugal, Madeira Island, Balearic Islands, and Morocco.

Double-hop sporadic-*E* paths can occur longer than two hours. However, it would seem that triple-hop and quadruple-hop openings generally would be of shorter duration. Therefore, imagine the idea of a five-hop or six-hop sporadic-*E* path being the primary model as shown in figure 3 between the U.S. and Japan lasting for an hour or more! Could there be a geophysical phenomenon that is unique for the days surrounding the Summer Solstice that could bepart of the reason for this path. If so, what phenomenon could this be?

Short-Path Summer Solstice Propagation (SSSP) Model

This unique path has had its share of observations. The paper "SSSP: Short-path Summer Solstice Propagation," written by Han Higasa, JE1BMJ, which was published in the September 2006 issue of the Japanese magazine *CQ Ham Radio,* and subsequently translated by Chris Gare, G3WOS, looks at another model besides the multi-hop sporadic-*E* model. This paper, which appears elsewhere in this issue of *CQ VHF* magazine, discusses the traditional multiple-hop sporadic-*E* model and then proposes a model that states that the 6-meter signal comes off at an appropriate takeoff angle into the ionosphere and never touches down in between. Typically, the stations from Japan who are worked via SSSP are running high power at 1 KW, and the signals are usually very weak, like EME signals.

This mode has been called the *whispering mode* in the past. Han suggests that the phenomenon Polar Mesosphere Summer Echo (PMSE)[1], which is characterized as a strong radar echo phenomenon that occurs in the polar regions at 80 to 90 km above the ground, may be involved. PMSE has been observed between 150 and 210 days a year between the end of May and the end of July, which matches the time frame for the Japan to North America events on 6 meters.

Han also states that the reason why this path seems to only happen on 6 meters is because: "The PMSE region refracts our 50-MHz signals especially efficiently, and I believe this to be one of the main reasons why SSSP has been reported on 50 MHz and not on 28 or 144 MHz for many years." Also Han states that it is hard to make definitive conclusions without supporting scientific observations by rockets and other means.

It has been observed that the Japan to U.S. path is not confined to only high-power stations. Jon Jones, NØJK, was able to complete a QSO with JA7QVI using his indoor 2-element Yagi and 100 watts in June 2006. He noted that JA7QVI had a solid signal that was easy to copy, in contrast to SSSP whisper weak signals noted by other stations. He also noted that on August 1, 2008, K7BG in Montana used 50 watts to work JL8GFB. Therefore, there appear to be two variations to the path, one where signals are strong (multiple-hop sporadic-*E*?) and one where signals are very week and require very high power (SSSP?).

The key component of the SSSP model is the fact that the signals would never touch the ground in between the stations, behaving in similar fashion to a chordal-hop *F2* skip that is observed during 6-meter long-path propagation. Thus, a purely SSSP-based model without any sporadic-*E* hops would be something like that depicted in figure 4. However, through examination of existing scientific literature such as the paper "Polar mesosphere

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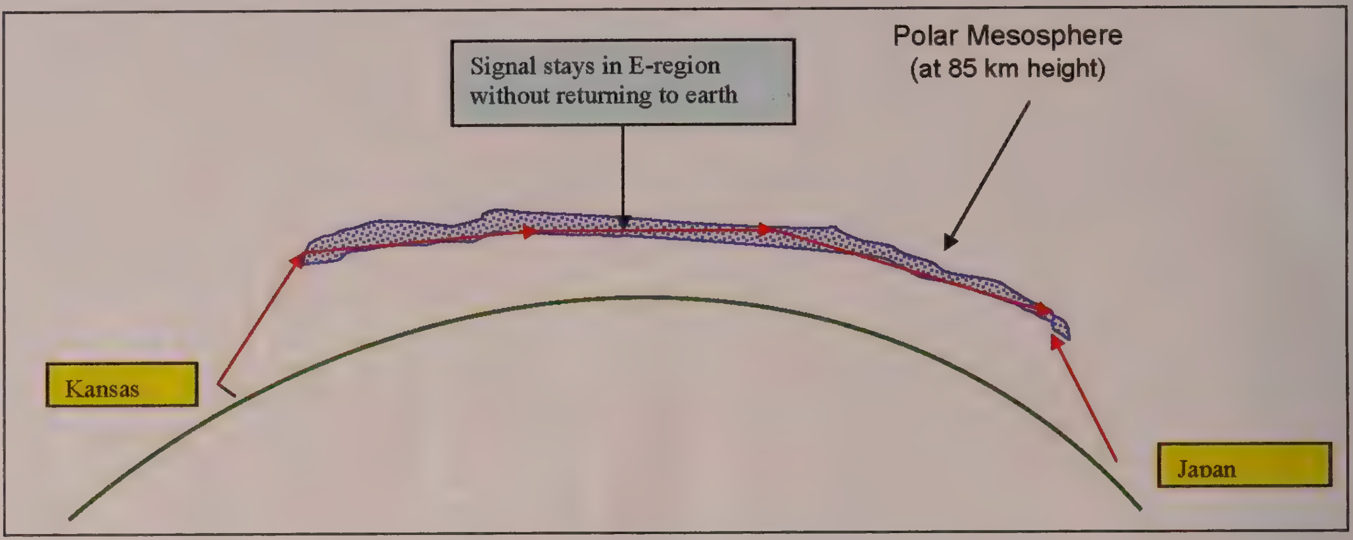

Figure 4. Theoretical SSSP model for a 50-MHz QSO between Kansas and Japan and no combinations.

summer echoes (PMSE): review of observations and current understanding" by Rapp and Lubken (Atmospheric Chemistry and Physics, 4, 2601–2633, 2004) one sees a number of observations that would make the model that is depicted in figure 4 highly unlikely.

For one thing, this paper notes that the lowest latitude (farthest south) PMSE has been observed is at 52 to 55 degrees N and as far north as 75 to 78 degrees N. Strong electron density of 5000 charged particles per cubic centimeter has been observed in the PMSE at 85 to 90 km above Earth. This is a slightly lower height than sporadic-*E* formations, which fall in the 90- to 105-km range. Thus, based on the height of this PMSE formation and the actual coverage of the formation, it seems highly unlikely that the formation alone is capable of sustaining signals in a chordal-hop fashion for such a long distance from the middle of the U.S. into Japan. In fact, based on the geometry, a PMSE formation may only cover the distance covered by two sporadic-*E* hops. Therefore, I believe that a more likely explanation that embraces both models is a combination of both sporadic-*E* propagation and a PMSE-based propagation mode. However, more data from the scientific side would be needed in order to support this theory.

It appears that stations located in southern Florida, southern Alabama, or southern Texas would have to be linked towards the northern U.S. via a sporadic-*E* link based on the fact that often the southern US stations can hear stations in the Michigan and Minnesota areas during the path into Japan. This would suggest at least one sporadic-*E* link based on the distance between the southern and northern U.S. Most likely, there would have to be a second sporadic-*E* path as well that goes from the northern sta-

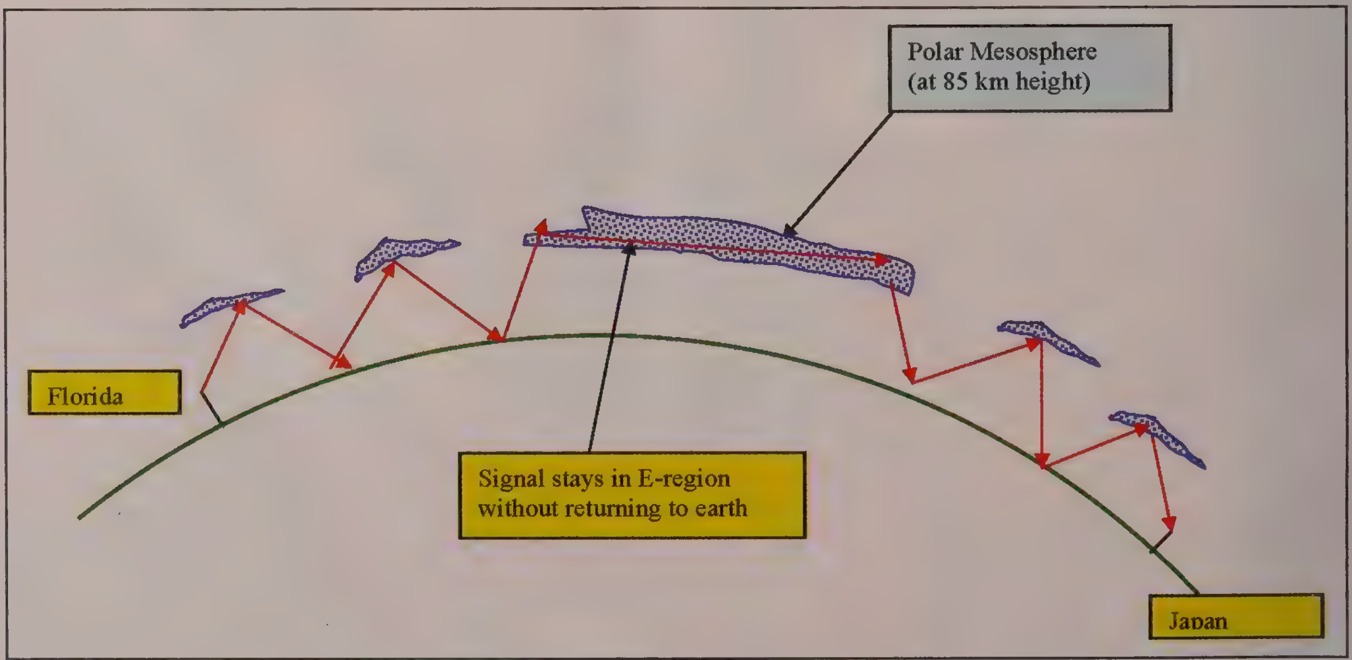

*Figure 5. Combined SSSP and sporadic-*E* model for a 50-MHz QSO between Florida and Japan.*

tions into the lower part of the Arctic region. Also with Japan having the highest incidence of sporadic-*E* in the world, there is most likely at least one, and perhaps two, sporadic-*E* formation that links the Japanese stations into the lower Arctic region from their end as well. Thus, a possible combination model using PMSE would look like figure 5, where there are sporadic-*E* formations that link into the PMSE formation, followed by additional sporadic-*E* formations.

Could there be a similar PMSE-type situation for the southern polar area on 50 MHz? The answer is possibly yes, but because of the small number of stations that are located in the southern latitudes—primarily Australia, Argentina, and South Africa—such a path would inherently be harder to detect. Also, it must be considered that the incidence of sporadic-*E* is not at the same level in this area of the world as it is in the area of Japan. Therefore, this reduced level of sporadic-*E* may be a factor as to whether such a path could appear in the Southern Hemisphere. (It is noted that the area of South Africa has the lowest incidence of sporadic-*E* during the year of anyplace in the world.)

Therefore, it now appears that the summer months' Japan to U.S. path is a unique path on 6 meters that does not seem to have any counterpart path in the Southern Hemisphere. The Northern Hemisphere path benefits from the large number of Japanese and North American operators on 6 meters, with many of them having excellent antenna setups and high-power capability.

In addition, besides this large number of hams on 6 meters, the active use of spotting sites on the internet has been a major factor in collecting data. One such site is run by ON4KST: <http://www.on4kst.info>. It saw a lot of international activity at key times during the day when Japanese stations were able to announce their operating frequency for U.S. stations to listen for them.

Now, what about events that occur outside the PMSE phenomenon window of the solstice period—i.e., openings that occur during the month of May or during the latter part of July? This may suggest that the multi-hop sporadic-*E* model would probably be more applicable and valid than the SSSP model. Indeed, this would leave us with two basic models, both of which are valid, with stipulations, as follows:

1. Multiple-hop sporadic-*E*—during May, June and July.
2. Sporadic-*E* hops plus PMSE—during Summer Solstice, around 0000 UTC.

Summary

There is still not enough information at this time to make any kind of conclusive statement regarding the probable propagation modes involved in a path between Japan and parts of the U.S. during the summertime sporadic-*E* season on 6 meters. There is no doubt that sporadic-*E* activity is at least a part of this path, regardless of which model is used.

The increase in observations has highlighted some characteristics of such a path, and observations of other long-range paths have provided some additional information with regard to the likelihood of several sporadic-*E* hops occurring at the same time for an extended period.

It would be great if there were ongoing scientific programs that could collect relevant data that would help determine what the geophysical phenomenon is that is involved in these unique 6-meter contacts. However, the sad truth is that there are currently a limited number of these programs and thoughtful speculation is all that can be done at this point. Eventually, science may catch up with ham radio observations, just as happened in the 1930s when the sporadic-*E* phenomenon and the aurora phenomenon both were discovered as a radio propagation mode on the amateur radio 5-meter band by U.S. hams.

Therefore, it is important that hams be encouraged to continue to collect such observations to make temporary models until the opportunity to improve upon these models can occur. The observations presented in this article are only a starting point, and more will be needed in order to better characterize the phenomena involved in this unique path. This will be a challenging area for 6-meter operators in the future!

Note

1. For further reading on PMSEs see: "Observation of polar mesosphere summer echoes with calibrated VHF radars at 69 degrees in the Northern and Southern Hemispheres," by R. Latteck, W. Singer, R. J. Morris, D. A. Holdsworth, and D. J. Murphy, *Geophysical Research letters,* Vol. 34, L14805, 2007.

Acknowledgements

I want to thank Jon Jones, NØJK; Bob Mobile, K1SIX; Dick Peacock, W2GFF; and Bill Holstein, KØHA for the data they collected and was used in this article. ■

SSSP: Short-path Summer Solstice Propagation

Two years ago, JE1BMJ developed a theory to explain long-distance propagation on 6 meters. While his theory has become somewhat dated and even he is re-examining parts of it, it is still considered a viable theory to at least partially explain the long-distance propagation. It is presented here as a means of comparision with WB2AMU's article, which begins on page 6.

By Han Higasa,* JE1BMJ

For many years DXers on 50 MHz have been surprised by the unexpected and excellent short-path propagation from Japan to Europe and North America. In 2006, short-path QSOs from W to EU and KL7 to EU were also reported. This propagation, which occurs around the Summer Solstice of June 21st, has generally been described as "multi-hop sporadic-*E*" and has been reported from the 1970s onward. I would like to ask: "Who undertook the surveys or deep studies on this type of propagation?" and "Why has it been assumed to be multi-hop sporadic-*E*?"

SSSP, or S3P, is an acronym for Short-path Summer Solstice Propagation, a name that Chris, G3WOS, and I have called this type of propagation and that I believe *not* to be based on multiple hops. SSSP has been discovered in the Northern Hemisphere, but symmetrically there should also be similar propagation at the December Solstice in the Southern Hemisphere. Because the December Solstice is called the Winter Solstice in the Northern Hemisphere, one might want to call it SWSP (Short-path Winter Solstice Propagation), but in this article I will refer to both SSSP and SWSP simply as SSSP to avoid any confusion.

Here I define SSSP as the short-path propagation around the June Solstice in the Northern Hemisphere and the similar propagation around the December Solstice in the Southern Hemisphere.

In June 1999, I first found SSSP through a 50-MHz CW QSO with Toivo, OH7PI, and up to the year 2006 I continued running propagation tests called "The Six Metre Propagation Test Campaign around the Summer Solstice." Although the amount of collected data is small and the exact mechanism is yet unknown, here I will introduce and hypothesize about the cause and nature of this type of propagation.

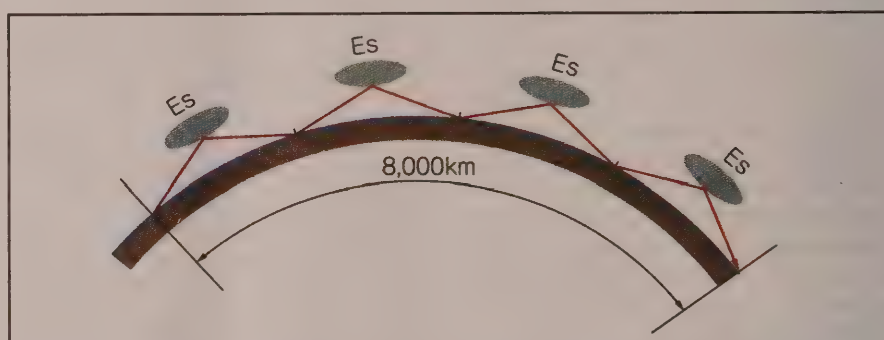

Figure 1. A model of "Multi-hop Es.*" We need to ask ourselves whether this is really correct.*

Why Has It Been Called "Multi-hop Sporadic-E"?

Figure 1 shows the usual model of multi-hop sporadic-*E*. In this model 50-MHz signals are refracted by *E*-layer clouds and reflected or bounced from the surface of the Earth several times between the transmitter and receiver—often described as one-hop or two-hop sporadic-*E*. However, I believe that assuming this mode of propagation stretches credibility when talking about summer short-path propagation between Japan and Europe.

Assuming the height of the *E*-cloud to be about 90 to 100 km, the maximum one-hop distance will be around 2,000 km. The distance of JA–EU propagation is between 10,000 and 12,000 km. Thus, the number of hops via classic multi-hop sporadic-*E* needs to be five, six, or even more. With JA–NA paths, we have a large area of sea on the path, but on the JA–EU path there is only the Eurasian continent and no water. Thus, the 50-MHz signal will be scattered and/or absorbed by the inefficient ground surface.

The short-path JA–EU QSOs seen this year are strong at the peak and the tone of CW signal is pure with little or no distortion—i.e., they do not appear to have been dispersed or scattered from, as would be expected, a signal that has been exposed to multiple reflections from the Earth's uneven ground. Such distortion can easily be observed on EME signals. Because of this issue, I am confident that the multi-hop sporadic-*E* model is not adequate to explain the propagation we have experienced this summer and for which I have adopted the term SSSP.

The Discovery of SSSP

In the spring of 1999 I acquired a special station license of 1 KW output for 1.8 MHz to 50 MHz. As in many countries, in Japan we need an explanatory document for the application of a 1-KW out-

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put license for 50 MHz. In my application I wrote that I wanted to study FAI (Field-Aligned Irregularities) in the *E*-region, as this was a newly found and currently unexplained phenomenon on the amateur bands. After the initial inspection of the KW station resulted in approval, I was praised by the inspection officer for the document explaining my requirement for high power on 50 MHz.

After a just a few months, on the evening of June 23, 1999, I found that the 48.25-MHz TV carrier from Europe was strong and I called CQ on 50.105 MHz. Almost immediately Toivo, OH7PI, called me. The QSO was the first QSO between JA and OH in Cycle 23. Toivo's CW signal was a pure tone with slow QSB of around 10–30 seconds. From that day, I called CQ every day on 50 MHz, and many stations in a wide variety of European countries (including SM, OH, G, GD, DL, SP, OZ, YO, F, PA) gave me received reports of my signal via the internet.

Furthermore, on July 10, a very strong opening started between JA and SM7FJE and around 35 JAs were lucky enough to have made QSOs to Europe. In addition, I completed a QSO with YO4AUL. This QSO has been recognized as the first YO–JA 50-MHz QSO following YO stations obtaining permission to operate on 50 MHz.

From 1999 to 2006 I have been running "The Six Metre Propagation Test Campaign" around the Summer Solstice and have called CQ on 50 MHz for many days every single season. I have often posted messages to the UKSMG announcement page regarding the campaign and discussed the nature of this propagation

However, reception of my views was not always particularly good. Almost all the contributors over the years thought that the widely accepted mechanism of multi-hop sporadic-*E* was the simplest explanation. Nevertheless, now I am happy to report that many other 50 MHz operators are open to the idea that this propagation is actually caused by a different mechanism, one that I have called SSSP.

A turning point was the unprecedented and totally unpredicted almost daily occurrence of strong JA–EU propagation during the summer of 2006 extending as far as the UK on several days. Table 1 shows a summary of JA–NA and JA–EU SSSP openings from 1990 to 2006. It is clear that the same kind of propagation occurs almost every year and is seemingly not influenced by solar activity; the peak of Cycle 22 was 1989 –1991 and the peak of Cycle 23 was 1999–2001. The year 2006 was the bottom of Cycle 23's solar activity. Please note "none" in Table 1 means no data was obtained. There is a possibility that propagation occurred. However, if it did it was not noted.

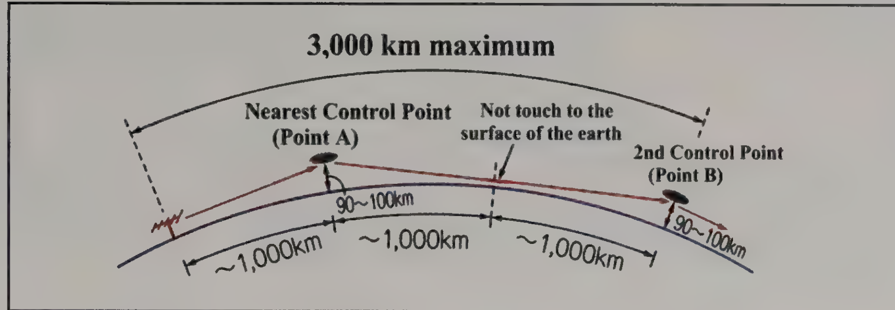

Figure 2. A model of the nearest control point of SSSP.

Characteristics of SSSP Propagation

The following is a summary of the characteristics of SSSP propagation obtained through my activity and tests:

1. Band: 50 MHz.
2. Period of occurrence: End of May through end of July every year (Northern Hemisphere) and around the December Solstice (Southern Hemisphere, extrapolated).
3. Time of propagation: JA–NA, 2100–0200 UTC, morning in JA, evening/night in USA; 0400–0900 UTC afternoon in JA, night/morning in USA; JA–EU, 0400–1000 UTC, afternoon in JA, morning in Europe.
4. Antenna direction: On or near short-path azimuth.
5. Paths: Mainly JA–NA, JA–EU. However, West Coast W–EU and KL7–EU have also been reported. Almost all paths are in the daylight area of the Earth and all are in the same hemisphere. (Note: To date, SSSP has been seen in the Northern Hemisphere only, but there is a possibility in the Southern Hemisphere.)
6. On JA–EU opening: 5Bs have frequently been reported (4X and ZC also but less frequently).
7. Length of openings: Open areas are "spotty" on both sides and move on a day-by-day basis.
8. Signal strength: Generally signals are weak with slow 10–30-second QSB and without any flutter. This is one of the features of the propagation that provides evidence that the signal path of SSSP never touches the surface of the Earth. More on this later.
9. Power: A high transmitter ERP is needed. Stations with 100 or 200 watts and a single Yagi are possible, but the crest time or usable time is short.

Possible Mechanism for SSSP Propagation

I will attempt to explain the core mechanism behind SSSP. Many of you know that I am just one of the many radio amateurs around the world who operate on 50 MHz and I myself have no way of directly measuring electron density in situ or by rocket-based observation. Even so, I am confident that SSSP has a different propagation mechanism from that assumed for multi-hop sporadic-*E*, the usual model accepted for this type of propagation.

Figure 2 shows the first control point (Point A) at which the 50-MHz signal is bent. I assume that point A could be located in either the *E*-layer or the higher *F1*-layer. If it lies in the *E*-layer, the height of Point A is around 90–100 km with a maximum one-hop distance of about 2,000 km. If the control point lies in the *F1*-layer, the height would be around 200 km and the maximum hop distance would be 3,000 km.

Please note that in the SSSP model the path never actually touches the ground. When it is assumed that Point A lies in the *E*-layer, the second control point (Point B) is a maximum of 3,000 km away from a station. If Point A is assumed to be located in the *F1*-layer, Point B is a maximum of 4,500 km away.

It is often said [Ref. 1] that the *F1*-layer is likely to occur in the daylight time of a summer season and constantly has an MUF of 4 to 5 MHz which is nearly independent of solar activity. When assuming *F1*-layer as the first control point of a 50-MHz signal, the incident angle should be less than five degrees by the secant law.

In the actual SSSP openings I have experienced, I have had to set my stacked Yagis

1990: June KL7
1991: May KL7
1992: June W6, W7; July YU, OK, OH, OE, DL
1993: none
1994: none
1995: July W6, W7, VE7
1996: July KL7
1997: none
1998: May W6; July W5, W6, W7
1999: June OH, SM, YO, W; July W5, W7
2000: June W5, W6, W7, W8, W9, WØ, KL7; July W5, W6, W7, W9, WØ, VE
2001: June W6, W7, KL7, SP, S5, 9A, OK, OZ, PA, HB9, OE, OH, DL, 5B, JY; July W6, W7, KL7
2002: June W6
2003: June W6, W7, VE, 5B; July W5, W6, W7, UXØ, Z3, 9H, LZ, 9A, SP, YU
2004: June I, SP, OH, ES, 9H, UT, 5B, W6
2005: June W7, 9H, G, SV8, LY, OH, YU, YO, I, 5B; July W6, W7, KL7, I, 5B
2006: May, June, July, many W and EU!

Table 1. SSSP openings from JA to NA and EU, 1990–2006

to an elevation angle of around 15 degrees compared to normal *F2* propagation when it is usually set to near zero degrees. Therefore, it is likely that Point A is nearer than the model shown in figure 2.

At the present time I believe that the *E*-layer is a more likely contender for the first control point at both the JA and EU ends of the path. I assume that the 50-MHz signal in Japan is bent at the first control point (Point A) above the Japan Sea and reaches the second control point (Point B) at around 55 degrees N, which is located near the Lake Baikal in eastern Siberia. From Point B the 50-MHz signal is carried by the region of "Polar Mesosphere Summer Echo" (PMSE). PMSE is a strong radar echo phenomenon obtained by radar observations at both north and south polar regions at around 80–90 km above the ground.

It is reported [Ref 2] that PMSE has been observed between 150 to 210 days of the year. PMSE also exactly matches the time period when we see SSSP propagation, between the end of May and the end of July. It is also reported that PMSE occurs at 52–78 degrees N in the Northern Hemisphere and has a Bragg Scale of three meters.

In regard to the explanation of PMSE and the Bragg Scale, I would recommend that you search the internet for further information, as there are many papers and articles on this subject. The paper entitled "Polar Mesosphere Summer Echo (PMSE): review of observations and current understanding" by M. Rapp and E. J. Lubken, 2004, can be obtained directly from <http://www.copernicus.org/EGU/acp/acp/4/2601/acp-4-2601.pdf> [Ref 2]. I believe this is the best paper for radio amateurs.

In this article I simply mention that the Bragg Scale of three meters can be translated to the frequency of 50 MHz. The PMSE region refracts our 50-MHz signals especially efficiently, and I believe this to be one of the main reasons why SSSP has been reported on 50 MHz and not on 28 or 144 MHz for many years.

The average height of the PMSE region is 88 km above the ground, which is by coincidence very near to the height of the *E*-layer. The PMSE region consists of suspended ice particles that are caused by the very low temperature of around 150°K at that height. Multiple studies regarding the polar mesosphere have reported that such a low temperatures are a result of the greenhouse warming effect that we are familiar with these days.

I would now like to attempt to explain the complete mechanism of SSSP (see figure 3). The *E*- (or *F1*-) layer provides the nearest control point for the stations at both ends of the link and the PMSE region connects the two control points over the polar region. The 50-MHz signal will be bent at the nearest control point and will propagate through the PMSE region covering the Arctic pole without ever touching the surface of the Earth. I believe this to be the core proposed mechanism of SSSP and provides a good explanation for the lack of distortion and the strength of signals I have observed in my study.

If SSSP does use the PMSE region as a type of chordal propagation, we can say that SSSP is a completely new type of propagation caused directly by the effect of greenhouse warming due to the activities of humans. For all of us, SSSP is a newly discovered propagation on our amateur bands. If so, that's really exciting!

We can monitor the electron density of the auroral oval in the Arctic polar area on a nearly real-time basis by looking at <http://www.sec.noaa.gov/pmap/pmapN.html>. On this page we can imagine how 50-MHz signals could propagate over the polar region.

Figure 4 shows the image of the auroral oval of the Arctic pole at 0600 UTC on July 19, 2006. This was one of the excellent days when I made many QSOs with European stations via SSSP. The map shows how a high electron density area covers the JA–EU path.

In the Southern Hemisphere, SSSP should also occur around the December Solstice. Operators on 50 MHz in ZS, VK, ZL PY, LU, CE, and other areas in the Southern Hemisphere are requested to look for this "*au natural*" gift as Christmas comes near!

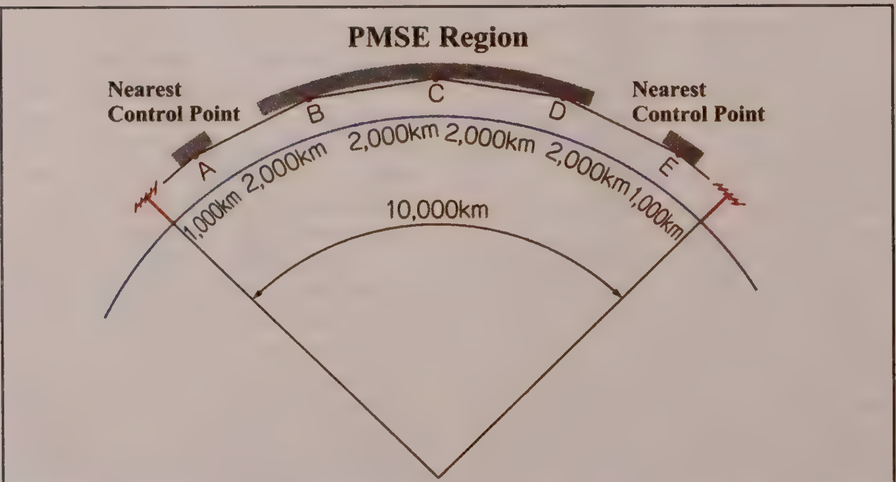

Figure 3. A model of end-to-end SSSP.

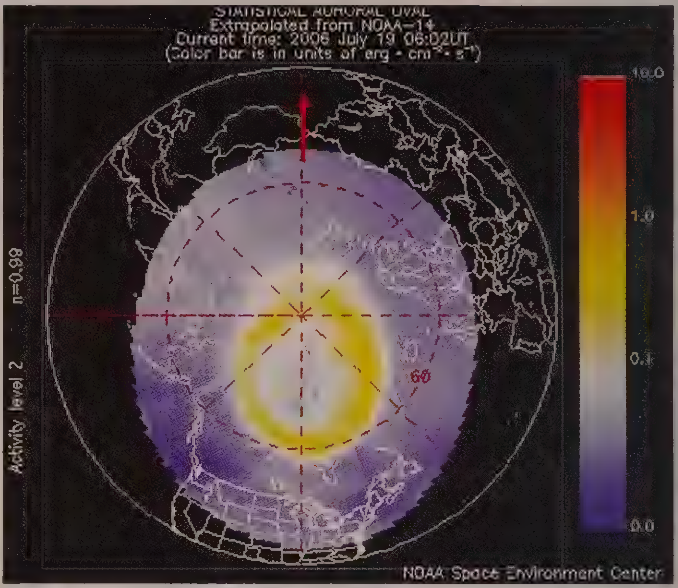

Figure 4. Map showing the electron density in the auroral oval at 0600 UTC on July 19, 2006.

Author Sidebar

While this article was written in 2006, I would like to point out that my opinions concerning my findings remain flexible. For example, I worked about 450 QSOs with North American stations—including KL7s, XEs, and HI3TEJ—in this 2008 season, and have reached the conclusion that we might need some other propagation model to explain the SSSP.

This model is much affected by geomagnetic activity; when the *K*-index is high, the auroral oval around the north pole turns to red (ref: POES-N graph page, meaning higher electron density) and the SSSP likely disturbed; when the color of the auroral oval is yellow to orange and has a thick area in the direction of the sun and the part comes to the midpoint of the two stations, the propagation will likely occur.

In this SSSP article I mentioned a connection to the PMSE and that the propagation will last until around the end of July. However, we experienced the opening toward EU and NA until the middle of August.

At least we can say that the path does not touch the Earth—meaning that it is a chordal hop—and as the path run through or near the auroral oval, it may be much affected by auroral activities.

Although the content of this original SSSP article is older than current knowledge, I think it is worth reading and considering as an introduction to the mystery of the natural phenomena, as well as what we need to address in the future.

One other point I need to mention in regard to SSSP is concerned with the elevation angle of my antenna. Figure 5 shows my current antenna system with 10 degrees of elevation angle. I am using two 10.7-meter boom, 8-element Yagis with an elevation mechanism. The stacking distance is 7.7 meters and the average height is 30 meters AGL.

I am using 35 meters of RG17A/U coax cable. The Yagis are based on the CL6DXZ from the Create Design company, optimized using the YO and AO software by K6STI. This horizontally polarized, vertically stacked pair of Yagis exhibits very high SNR (signal to noise ratio) on 50 MHz compared to a single Yagi configuration because of the sharp and clean radiation pattern in the vertical plane.

Additionally I am using a TS-940 and FT-1000MP with a homebrew transverter and a 1-KW output linear amplifier. The receiving converter consists of a 2SK571 VHF FET and a double balanced mixer. This converter exhibits a low noise figure and high gain, which is good enough for my DXing activities. My S-meter always reads S1 to S2 because of the high gain of the converter and because of artificial noise from the residential area surrounding my shack. However, I need high sensitivity, especially on 50 MHz.

The high dynamic range and noise blanker of the legendary HF band flagship transceivers address these challenging operating conditions. In the Japanese market these old transceivers can be obtained at affordable prices, and they are very well suited for combining with 50-MHz transverters.

To buy one of these inexpensive transceivers second hand and use a tall tower with large or stacked antennas and low-loss large diameter coax for 50 MHz is the best way. Through understanding and realizing the law and the rules (yes, Zen and the Art!), building an excellent system is not difficult today.

When I increase the elevation angle of my Yagis (for instance from 0 to 10 degrees), the level of incoming noise decreases substantially, by up to 6–10 dB. This is because of the elimination of nearby noise interference received on the underside of the main lobe. When further increasing the elevation angle, I frequently observe that the DX signal can be heard clearly, whereas the level of interference rapidly decreases. As a result, the SNR of DX signals is much improved and this is very helpful when copying weak signals buried in the buzz when using SSSP.

In this year's sporadic-*E* season, from the end of May to the end of July 2006, I made some 180 QSOs with EU stations, including HVØ, and 80 QSOs with NA stations, including W, VE, and KL7. For almost all of these SSSP QSOs I found that the optimal elevation angle was in the range of 10–15 degrees, although this maybe a particular result of my own location, system, and the antenna. As the exact propagation characteristics of SSSP propagation are still unknown, the general access angle of elevation is also unknown. I heard stations using a single Yagi without elevation and they were making SSSP QSOs quite easily. They had a broad main lobe and could attain literally a wide range of propagation.

Stations with stacked Yagis should have a high SNR and a low elevation angle, but without an elevation mechanism they will ultimately suffer poorer SNR because of the weak DX signal from higher elevation angle and the loud TV buzz being simultaneously received. I recommend a single long-boom (1.5–2.5 WL) Yagi with or without an elevation rotator, or vertically stacked Yagis with an elevation rotator for SSSP. Although a single Yagi has a broad main lobe and can easily adapt to any of the types of propagation encountered on 50 MHz, the elevation mechanism will also make sense in improving the SNR of weak DX signals.

The Great Days of SSSP

Figure 6 shows the GoogleEarth propagation map (http://www.dxers.info/ google/earth/index.php) that Chris, G3WOS, downloaded on June 14, 2006. The paths—including JA–EU, JA–5B, and JA–5T are indicated on it.

On that day I had QSOs with G4IGO, G3WOS, G4FVP, SV1LK, SV1SB, 9A6R, G4RGK, and some Italian stations. Amazingly, Nicolas, 5T5SN, gave me a report from Africa, about 13,500 km away!

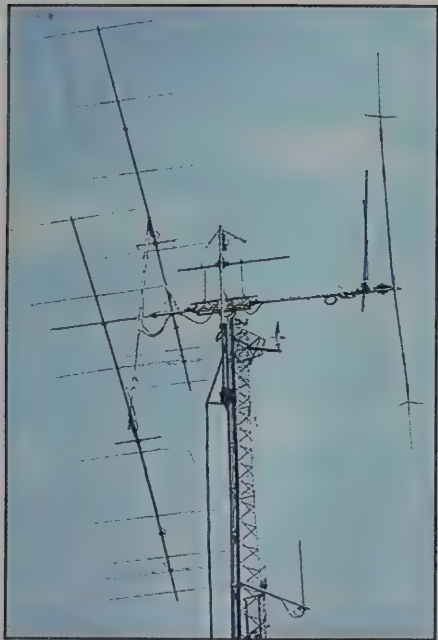

Figure 5. JE1BMJ's 10.7-meter boom, 8-element Yagis stacked 7.7 meters apart with an elevation rotation mechanism.

On July 19 (see again figure 4) I completed QSOs with the following stations: NL7Z, DK1MAX, I5IAR, ON7GB, DL7QY, OH2BC, I5TAT, DJ3TF, LY3UM, LY3DA, DL3BUE, SM3GSK, OH2BP, ON7BJ, DL7CM, DL2OE, F8ZW, OH2MA, DK3WG, DM2AYO, ON4AOI, PA3GND, DJ2BW, and others.

Conclusions

Although there are still many unresolved or unknown phenomena in relation to SSSP propagation at the present time, I hope many 50-MHz enthusiasts will continue to survey, research, and exploit SSSP. For reasons outlined in this article, this newly discovered mode of propagation provides QSO opportunities across great distances that were either unattainable or unnoticed in the past.

Our primary goal should be to take advantage of this opportunity which provides considerable excitement equivalent to that experienced at the peak of the solar cycle using *F2* propagation. SSSP even occurs in the dip of a solar cycle. I look forward to having an SSSP QSO with many of you on 50 MHz in the near future!

Acknowledgements

Thanks to all the 50-MHz DXers who are using SSSP every season. And my special thanks to Chris Gare, G3WOS, who assisted in the naming of this propagation, producing the GoogleEarth map, and editing English for this article. ■

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The Basement Laboratory Group: A Pioneering VHF Club

Part 2 – Walt Morrison, W2CXY

This second installment of WA2VVA's look back at our pioneers focuses on someone dear to him, his father.

By Mark Morrison,* WA2VVA

The factory in Newark, New Jersey is now silent. No longer do the dynamos run there, singing their distant song. No longer does the arc light cast its brilliance upon the ground below, nor do the cobblestone streets surrounding this place give any clue as to what happened there so many years ago.

However, in the not-so-distant past, this place was a beacon for industry and technology. It was here that the standards for measuring electricity were first established, born of necessity in the developing years of the second industrial age. Thomas Edison lived nearby, as did the captains of industry.

Yet for one inventor, a chemist by trade, work was a passion and this place was home. This was the Weston Electric Light Company, founded by Dr. Edward Weston, holder of over 300 patents and contemporary, nay competitor, of Thomas Edison. Weston's factory in Newark was the first of its kind, dedicated to the production of finely crafted carbon arc lamps and the dynamos needed to run them.

Weston equipment was used in some of the earliest examples of public lighting, first in Newark and then in major post offices and parks across America. In 1883, Weston equipment was even used to illuminate the Brooklyn Bridge. In 1887, Weston invented the first truly permanent magnet that would become the backbone of electrical measuring apparatus for decades to come.

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Figure 1. Photo of a Weston Electric Light Company employee in 1938.

Weston also invented a photo-electric cell that was used in photographic exposure meters popular at the time. Weston's greatest achievement, however, may have been his founding of the Newark Technical School, now the New Jersey Institute of Technology, where many a young man got his start in the age of power and lighting.

One such man was Walter Morrison, who as a young man in the 1930s worked at Weston by day and attended Newark Technical School by night. This was a good fit, as Weston made instruments for photography as well as radio, both avid interests of Walt's. On at least one occasion, Walt brought his camera to the Weston Instrument facility on Frelinghuysen Avenue for a behind-the-scenes look at the place. The photograph in figure 1 from 1938 shows one of Walt's co-workers at the controls of a Model 766

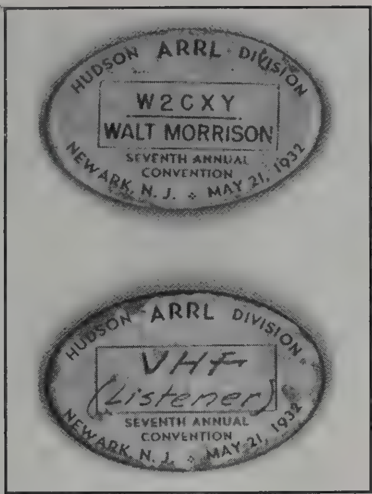


Figure 2. Pins from 1932 ARRL Hudson Division Convention.

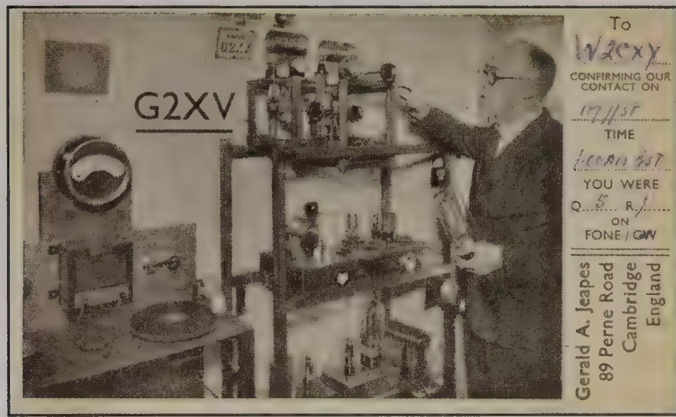


Figure 3. QSL card of Gerald Jeapes, G2XV.

direct-reading oscillator, part of a trio of products marketed for the new field of FM radio, the latest invention of radio pioneer Major Edwin Armstrong.

Completing the trio were the Model 772 Super-sensitive analyzer and the Model 787 UHF oscillator, the latter tunable from 22 MHz all the way up to 150 MHz. Weston advertised that such a wide frequency range "safeguards against obsolescence in the event of changes in assigned frequencies." Those familiar with the tragic story of FM radio can appreciate that statement.

In 1931, at the age of 17, Walt received his first and only call, W2CXY. Almost immediately Walt showed an interest in VHF communications, as illustrated by the pins shown in figure 2 from the 7th Annual ARRL Hudson Division Convention held in Newark the following year.

While Walt may have been "listening" on VHF, he was "talking" on the HF bands, as illustrated by the QSL card shown in figure 3 from July 1938. Note what appears to be a large Weston meter on the left of the picture.

Later that same year the CBS Radio Network aired Orson Welles' historic "War of the Worlds" program, creating panic among the listening public and traffic jams as many sought the safety of the surrounding hills. Whether Walt was among them is unknown, but the photo

Figure 4. Photo of Walt Morrison and Edna Carhart in Long Valley, New Jersey.

Figure 5. Photo of the VHF antenna collection near Newark, New Jersey.

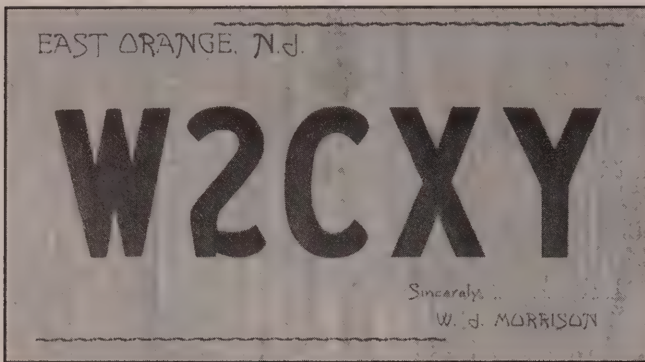


Figure 6. QSL card of Walt Morrison, W2CXY.

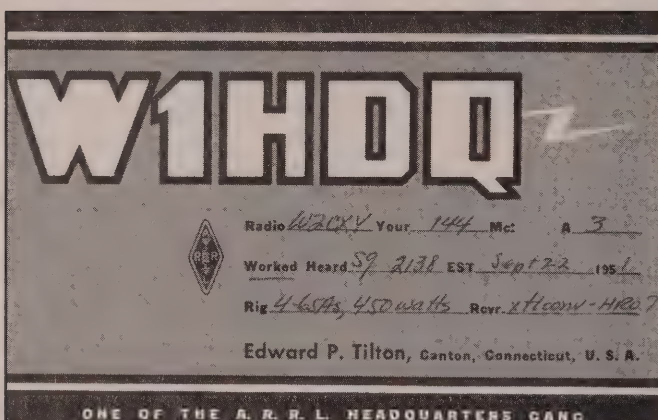


Figure 7. QSL card of Ed Tilton, W1HDQ.

in figure 4 suggests he would have been well-prepared. It shows Walt and another Weston employee, his future wife Edna Carhart, resting beside his 1936 Ford in Long Valley, New Jersey. Note the vertically polarized Yagi antenna supported by bamboo poles. The Yagi was only introduced to the U.S. in 1932, so this is arguably one of the earliest uses of such an antenna for mobile/portable use. The 2-meter band was not allocated to amateurs until 1945, so this may be a $2^1/2$-meter antenna.

In 1940 Walt left Weston to work for the Prudential Insurance Company, one of the greatest friends that Newark has ever known, and full of opportunity for young engineers interested in the growing field of power and lighting. Walt worked in the Architecture and Engineering Division, where he designed power and lighting systems for the many buildings that "the Pru" would construct for itself and others. Walt worked there for 40 years before retiring in 1982.

The tightly spaced houses in the suburbs of Newark made it challenging to erect serious VHF antennas, but Walt and his friends were up to the task. This picture, figure 5, shows how far serious hams were willing to go back then. The tower as shown and the many VHF beams belonged to one of Walt's friends.

In the 1940s Walt and his family moved to the town remembered in the "I Love Lucy" television series when Lucille remarked, "The traffic was backed up all the way to East Orange, New Jersey!" Figure 6 is Walt's QSL card from the era. Walt and his family lived on North Grove Street.

Walt's logbooks are very detailed from the 1940s into the 1950s. The earliest entries reveal names that would become lasting friendships, including one QSO dated April 7, 1951 with BLG founder Carl Scheideler, W2AZL. On subsequent pages we see other familiar names, including East Coast VHF legends such as Tommy Thomas, W2UK, and Ed Tilton, W1HDQ. The QSL in figure 7 confirms a QSO between W2CXY and Ed, also in 1951.

In 1953, when W2UK and Paul Wilson, W4HHK, first experimented with meteor scatter on 144 MHz, it was Ed Tilton who established the requirements for a valid contact. When Tommy and Paul finally met those requirements in 1954, they were credited with the very first meteor-scatter QSO ever made on 2 meters, something for which they received the ARRL Merit Award.

The "Basement Laboratory Sessions" were held most Thursday evenings at the QTH of Carl Scheideler, W2AZL. This informal gathering of "underground engineers," as W2UK would refer to them, provided an opportunity for VHF operators to meet and discuss various VHF projects. One such project even got the attention of the U.S. Army as illustrated by a curious letter Walt received from the U.S. Army Map Service in May of 1955. This letter was in response to Walt's proposition to use the moon as a reflector of coherent light waves for communications purposes.

Walt may have gotten the idea from the Century of Progress Exposition years earlier when Dr. Weston's innovative photoelectric cell was used to detect light from the star Arcturus and then trigger the huge arc light that symbolized the beginning of that great event. Included in the Army response was a three-page letter from Mr. John O'Keefe, the man later credited with the discovery of the Earth's pear shape and a champion of the laser reflectors left on the moon by Apollo astronauts.

Unfortunately, the response was not encouraging, as a suitable source of coherent light had not yet been invented. However, when the laser was invented some years later, MIT scientists proved that it could be done. It is interesting to note that Mr. O'Keefe's letter suggested a potential mode of VHF communications that to my knowledge has not yet been exploited. Details will be revealed in a future article.

Many antenna parties brought people together for the express purpose of getting someone on the air. Figure 8 is Walt's array in 1956, shortly after it was erected by "the basement engineers" at Walt's new QTH in Chatham, New Jersey. The tower was 70 feet tall.

Walt's station included an AN/ARC-1 military transceiver for local 2-meter work, and a modified SCR-522 driving 150 watts into a pair of 4-125As for DX work. On the receiving side, the classic W2AZL crystal-controlled converter provided IF output to a Collins 75A-4 receiver. Accessories included an audio filter salvaged from a surplus RAK-7, a Lamb Noise Silencer, and a "Panadaptor," the latter used for watching and chasing meteor-scatter "pings" in real time. A Collins KWS-1K (identical to the KWS-1 but without the matching power supply) was used for HF liaison work setting up schedules and assisting with VHF contacts.

Many amateurs collaborated on building projects, often following plans written by amateurs and published in *QST, CQ, 73* and *ham radio* magazines. Carl Scheideler's 417A crystal-controlled converter became a classic after its appearance in *QST*. Carl and Walt spent hours building these converters and either giving them away or selling them to others. In the 1990s

Figure 8. The 2-meter array of W2CXY in Chatham, New Jersey circa 1956.

Walt found one at a local ham flea market and recognized it as one that he had constructed. It was easy to tell from the trademark thumb screws that he used on such projects.

Some of the hams in the W2CXY logbook became well known in VHF circles years later. The QSL card in figure 9 is from 14-year-old Joe Taylor, now recognized as the Noble Prize winning Princeton physicist who recently revolutionized meteor-scatter communication with his WSJT signal-processing software. This software makes it possible to complete meteor-scatter contacts practically any time of the year.

In the 1950s flexible-film tape recorders became popular, and many amateurs used them to record and share their work with others. Although nothing could replace a good ear for making contacts, audio recordings provided objective evidence that such contacts had been made. W2CXY recorded the signals of many others during VHF contests and schedules. Some of his more memorable recordings are those of WØIFS, KØEMC, W5RCI, W5AJG, W4LTU, and W5FAG, all with ranges greater than 1000 miles at a time when 500 miles was something to brag about.

Just as important as tape recordings were the written listening reports, as these could indicate potential DX paths. One example, figure 10, is a report from Bob Turk, W7LEE, in Parker, Arizona, who reported hearing W2CXY on 2 meters in 1956, representing an amazing 2100 miles! Note that the record-breaking contact between BLG associate Tommy Thomas, KH6UK, and John Chambers, W6NLZ, was still a year away, so this was big news to the amateur radio community. Those familiar with the *Perseids* meteor shower should recognize the date on this card.

In 1956, Walt organized a large group of hams for a Christmas audio tape to be sent to Tommy Thomas, KH6UK, and his wife Helene in Hawaii. Walt documented the voices of many old timers and VHF pioneers, including Carl Scheideler, W2AZL, Paul Wilson, W4HHK, Walt Bain, W4LTU, Frank Lester, W2AMJ, Tony Shepard, VE3DIR, and others. Many of them described their accomplishments for 1956 and what they hoped to accomplish in 1957.

One of the hams Walt recorded on his Christmas tape was Paul Wilson, W4HHK, the person credited with making the first meteor-scatter contact on 2 meters with Tommy Thomas, W2UK. The card in figure 11 documents what Paul believed to be the first New Jersey to Tennessee aurora contact on 144 MHz.

In 1957, Walt assembled this "stovepipe final" VHF amplifier with input and output cavities tunable from 60 MHz to 450 MHz (see figure 12). He adapted it to use Eimac's new 4CX1000A, which Walt received from Eimac for evaluation.

Representatives from Eimac showed quite a bit of interest in this device. One demonstration for a top Eimac rep involved a pencil being stuck into an access hole, which promptly lit the pencil on fire! This part of the station is now on Long Island, New York.

In 1957, the official beginning of the International Geophysical Year (IGY) provided an opportunity for VHF enthusiasts to contribute toward the understanding of the world around them. The ARRL published a special newsletter for the purpose of documenting the events and calls of those participating. The Propagation Research Project, as it was called, allowed amateurs around the world to coordinate their activities and share findings with other "observers." This was also the dawn of the space age, and for the VHF enthusiast, an opportunity to explore and document the unknown.

The IGY got off to a big start when the Russians launched Sputnik in October 1957. The logbook of W2CXY shows that

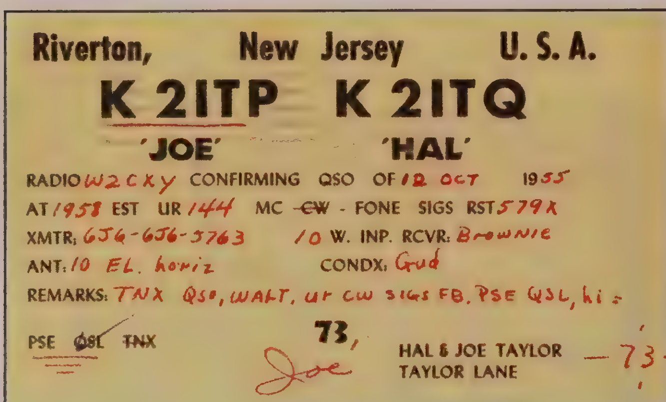


Figure 9. QSL card of Joe Taylor, K2ITP, circa 1955.

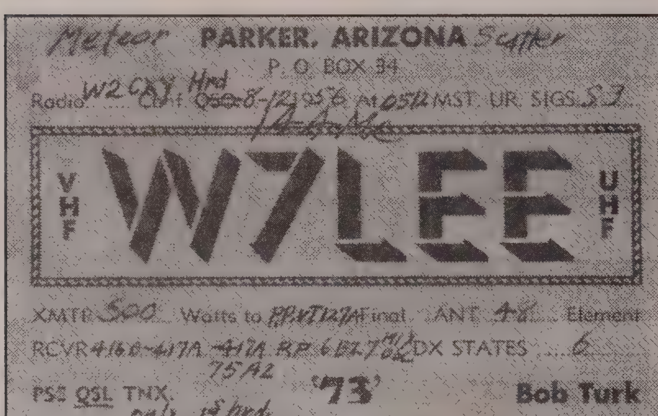


Figure 10. QSL card of Bob Turk, W7LEE, circa 1956.

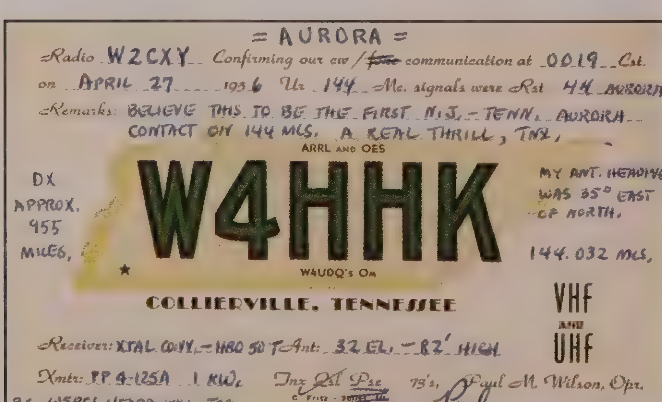
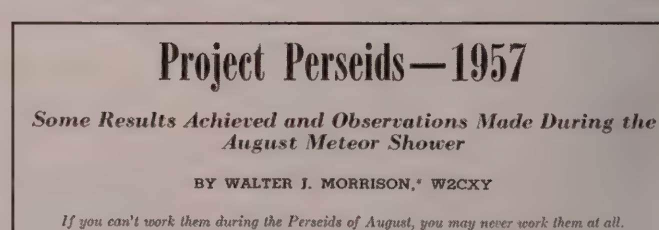


Figure 11. QSL card of Paul Wilson, W4HHK, circa 1956.

Figure 12. Photo of W2CXY with the "stovepipe final" VHF amplifier, circa 1956.


Project Perseids—1957

Some Results Achieved and Observations Made During the August Meteor Shower

BY WALTER J. MORRISON,* W2CXY

If you can't work them during the Perseids of August, you may never work them at all.

Figure 13. Article by W2CXY from QST, November 1957.

he monitored the Russian satellite in the first few days after its launch. Something else the logbook shows are the numerous 2-meter contacts Walt made that year, including those needed to win the ARRL VHF contest for top one-band score. Walt described meteor-scatter operations in the November 1957 issue of *QST* (see figure 13).

Ever vigilant in his quest to expand the 2-meter horizon, in 1958 Walt coordinated transatlantic tests with amateurs in Holland (see figure 14). Although success eluded them, this was one of the earliest coordinated 2-meter tests across the Atlantic and possibly the only one conducted as part of the IGY.

144-Mc. Transatlantic Tests

The information for this item came to us the long way 'round; PRP observer Walt Morrison, W2CXY, came up with the idea, sent it off to the Radio Society of Great Britain, and we read about it in the March, 1958 RSGB Bulletin. Walt feels that neither meteor nor auroral propagation look too good for accomplishing that dream of two-meter operators, a transatlantic contact. He believes that three possibilities remain -- ionospheric scatter under conditions of intense F2 layer ionization, moon bounce or tropospheric propagation. Whatever the mode of propagation, then, the signals, if there at all, will be extremely weak. Obviously an emulation of the W6NLZ-KH6UK effort is called for, making use of the best possible equipment.

W2CXY will operate on 14.095 Mc. and 144.01 Mc. simultaneously transmitting "IGY TEST IGY-TEST IGY TEST DUAL 14095/144010 DE W2CXY" at about 20 w.p.m. for five minutes commencing at 1330, 1900 and 0300 GMT (0830, 1400 and 2200 EST) on Saturdays and Sundays and at 2330 GMT (1830 EST) Mondays to Fridays. The five-minute transmission period will alternate with similar listening periods on both bands.

Equipment to be used by W2CXY includes a Collins KWS-1K running 1 kw. to a ground plane on 14 Mc. For 144 Mc., the transmitter comprises a modified SCR522 driving push-pull 4-125As also running 1 kw. input and feeding a 40-element array consisting of four 16 ft. long yagis spaced 12 ft. by 12 ft. on a 70-ft. tower. A new coaxial final using an Eimac 4CX1000A tunable from 60 to 450 Mc. will be completed soon. The station is 350 ft. above sea level with a relatively clear path to the Atlantic 20 miles north-east of Chatham, New Jersey. Best of luck Walt!

Figure 14. From PRP News.

In April of 1958, Walt wrote an article for *CQ* magazine entitled "Modern Dilemma—144 Megacycle Style" in which he described a real-life situation involving late-night VHF openings into rare DX territory. The dilemma was whether or not to alert his meteor-scatter partner Carl, W2AZL, to a rare opening with Ruddy Ellis, W4LNG, at the risk of disturbing Carl's family.

During the summer of 1958, Walt took best DX by working the *Perseids* meteor shower and rose to the top of the 2-meter standings. The "2-meter standings," published monthly in *QST*, was the "Who's Who" of VHF operators. This single achievement ensured Walt a spot in the column for the next 16 years.

Operation Shotput provided a unique opportunity for VHF enthusiasts to extend the reach of their signals. In October of

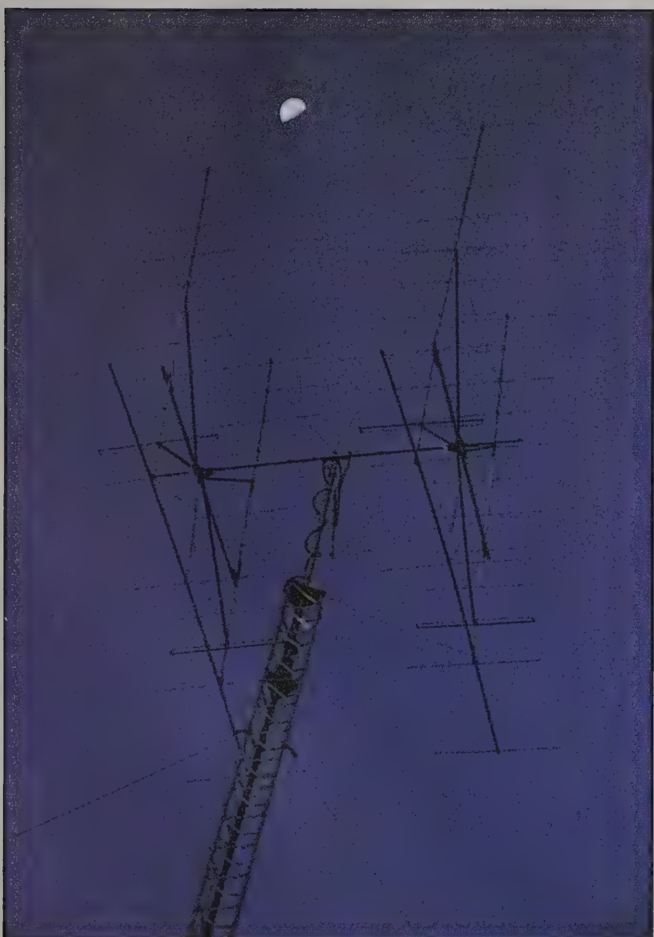


Figure 15. W2CXY 2-meter array positioned for a moon-bounce attempt.

Figure 16. The W2CXY Klystron and magnet power supplies, circa 1959.

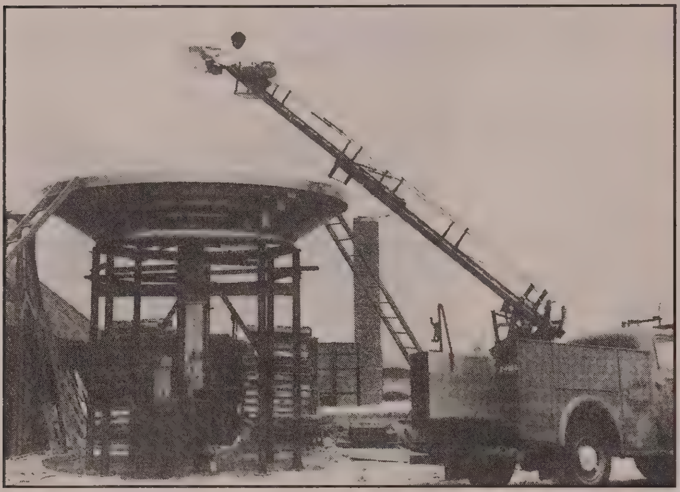


Figure 17. General bronze dish, from Scatter Propagation Theory and Practice, *published by Howard W. Sams in 1956.*

Figure 18. W2CXY dish, Chatham, New Jersey, circa 1962.

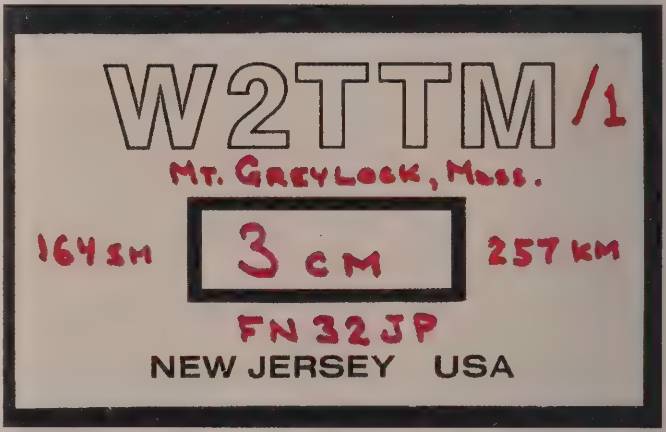


Figure 19. QSL card of Ed O'Connor, W2TTM.

1959, an aluminized Mylar balloon was launched from Wallops Island, Virginia. This was the first (vertical) launch of the ECHO satellite series, something that allowed testing to be performed prior to putting an actual satellite into orbit. Although the balloon ruptured into thousands of pieces that resulted in a spectacular sight visible all the way to Canada, it provided a once-in-a-lifetime opportunity for the few amateurs who participated, including W2CXY. Signals from all along the East Coast could be heard from W2CXY and others as they successfully bounced their 2-meter signals off the surface of this artificial satellite.

Because the balloon was only at altitude for about 12 minutes, those who participated had to scramble to get on board. What is significant is how Walt and the others used this balloon for communications purposes a full eight months before Bell Labs did the same thing with the orbiting version of ECHO1. I often wonder if Carl Scheideler, who worked for Bell Labs at the time, might have given Walt and other East Coast VHF enthusiasts advance notice of this rare opportunity. This is believed to be the first time any kind of manmade space reflector was used for amateur communications.

Early moonbounce work was attempted by many amateurs already established with high-power 144-MHz stations. First attempts usually involved pointing the beam toward the moon, with no particular method of tracking its motion. This was easiest to do when the Moon was on the horizon. Many discovered the ground gain that could be achieved in this manner. Although the legal limit for 144 MHz was 1 KW at the time, it was generally believed that sufficient antenna gain was needed on both ends of the circuit in order to be successful. Most considered 19 dB the minimum gain required. This meant stacked Yagis and high power. Figure 15 shows Walt's array positioned for an early 144-MHz moonbounce test.

Some experimented with extra-long Yagis, referred to as "Long Johns," while others thought collinear arrays provided more directivity. In the end, while many amateurs reported hearing their own echoes, especially when the Moon was low on the horizon, the size of the array, the height of the tower, the requirement to track changes in altitude and azimuth, and everything else needed to make it work were big challenges.

More attractive in some ways was the parabolic dish, available as military surplus, which offered high gain in a compact size. Of course that meant moving from 144 MHz to the higher bands, such as 432 MHz or 1296 MHz, and for many a VHF station, this was akin to starting over. A 432-MHz station could be assembled using components similar to those used for 144 MHz, but since the legal power limit was only 500 watts, 432 MHz was not favored for moonbounce. The next logical choice was 1296 MHz, where the legal limit was 1000 watts.

The prospect of doing serious moonbounce work posed something of a dilemma for Walt. Not being able to support simultaneous 144 MHz and 1296 MHz setups, he apparently dropped out of 144 MHz to dedicate his time and resources to building the first amateur UHF moonbounce station in the State of New Jersey, and one of only three in the United States (the others being W6HB and W1FZJ at the time).

In 1959, Walt contacted the Eitel-McCullough Company (Eimac) to express interest in constructing an amateur 1296-

MHz moonbounce station, if only the necessary Klystron components could be obtained. As a result of his efforts, not only did Eimac provide such equipment at no cost, but later followed up with perhaps a dozen such devices for others, including Tommy Thomas, KH6UK, and John Chambers, W6NLZ.

The picture in figure 16 shows the Eimac Klystron (right) and the rack-mounted magnet power supplies built by W2CXY (left) prior to being relocated to Infoage in Wall, New Jersey.

While Carl Scheideler, W2AZL, and Bill Ashby, K2TKN, provided assistance on the receiving side of the W2CXY moonbounce station, Ed O'Connor, W2TTM, helped locate and transport a 15-foot parabolic dish from Long Island, New York to Chatham, New Jersey. The dish was a "precision parabola" constructed by the General Bronze Company (well known for its radio telescope work at Arecibo) and specifically designed for SWR test purposes. The picture in figure 17 shows Walt's dish, or one identical to it, being used for feedhorn testing at the General Bronze facility in the 1950s.

The year 1960 was the year that radio amateurs first bounced radio signals off the moon for a valid QSO. Although Walt did not participate in that historic QSO, he was part of the chain of events that helped make it happen. Hank Brown, W6HB, of Eimac later credited Walt as being part of the motivation for making it all happen. Here's what Hank had to say in his September 1960 *QST* article:

> The project received a tremendous boost when Walt Morrison, W2CXY, contacted Hank and told him of East Coast interest in the undertaking. Accordingly, several Eimac u.h.f. transmitting klystrons were modified to reach a frequency of 1296 MHz and one was shipped to Walt, and another to Sam Harris, W1FZJ.

The Chatham location was really flat, with space for working outside on beams and towers. In 1961, Walt turned attention to getting his dish up and running. At the peak of the space race, a parabolic dish in the backyard (see figure 18) was something unusual. People would often slow down as they drove down the street and a few of the more curious actually got out of their cars to take a closer look. Walt's dish was last owned by Ed O'Connor, W2TTM.

On the evening of March 15, 1962, Walt's team—which included Ed O'Connor, W2TTM, Carl Scheideler, W2AZL, Bill Ashby, K2TKN, and a few others—succeeded in bouncing a 1296-MHz signal off the moon into the dish of W1BU in Medfield, Massachusetts. Sam Harris, W1FZJ, had this to say in the May 1962 issue of *QST*:

> W2CXY and his group of basement engineers, which includes such notables as W2AZL, K2TKN, K2GQI, W2HAC [s/b K2HAC] and others too numerous to mention, are also on the air both transmitting and receiving. As a matter of interest I did receive a short transmission from them by way to the moon on the night of March 15—the first moonbounce signal we have heard at W1BU since August of 1960.

Considering that Walt's signal was the first to be heard by Sam since 1960, W2CXY appears to be the third amateur station to ever reflect a 1296-MHz signal off the moon to be heard by another station.

In the 1970s, Walt kept a low profile on the VHF bands, but did maintain a presence on 2 meters by installing a Drake TR-72 in his Ford Pinto and traveling around the country. Walt attended many of the Central States VHF Society Conferences with his good friend Carl, W2AZL, finding particular enjoyment in the VHF pre-amplifier noise-figure contests.

In the 1980s, Walt rediscovered the thrill of making contacts in the "World Above 50 MHz," only this time on 10 GHz. BLG member Ed O'Connor, W2TTM, and others had been active on this band for some time and encouraged Walt to get back into the action. Walt took up the challenge in typical fashion: Build it yourself and build it big! While most of his friends chose the ubiquitous RCA satellite TV dish and gunplexer setup, Walt went with a 4-foot spun-aluminum dish and the less common Traveling Wave Tube (TWT) amplifier. Here was all the thrill of making your own equipment, setting it up on mountaintops, and working schedules again. Some of the hams Walt worked on 2 meters in the 1950s were worked again on 10 GHz. The QSL card in figure 19 documents just such a contact between Walt and Ed O'Connor, W2TTM, in August 1990. The inscription on the back reads:

> Walter,
>
> Happy to be your first Mass. contact & your best 10 GHz to date. This is like reliving the old days on 2 mtrs.
>
> 73, Ed

For 10-GHz operations Walt and his friends seemed to favor the historic Twin Lights Lighthouse overlooking Sandy Hook, New Jersey. Once the home of a great arc light, this place provides a spectacular view of the Atlantic Ocean and New York City. Marconi chose this site for radio tests some 100 years earlier (in 1899) and later established the first wireless telegraph station in the U.S. that was capable of both transmitting and receiving on a regular basis. It was also from this site that Walt completed his final QSO.

The Twin Lights Lighthouse once had its own power house, complete with dynamos and steam engines that powered the great light until 1917, when it was deemed too expensive to keep operating. However, now the lighthouse is silent. No longer do the dynamos run there, singing their distant song. No longer does the arc light cast its brilliance upon the ground below, nor do the cobblestone streets surrounding this place give any clue as to what happened there so many years ago. However, in the not-so-distant past, this place was a beacon of industry and technology.

VHF-Plus Contesting on a Shoestring

Many of us hope that our progeny consider taking up our wonderful hobby. Here K7SZ describes his initial successes with his grandson Llyam.

By Rich Arland,* K7SZ

Occasionally something happens that makes me think our ham radio hobby has an actual chance of enduring into the foreseeable future. Ergo, my 11-year-old grandson, Llyam. A couple of years ago, while working on the ARRL's QRP book, Llyam approached me about possibly building one of the small QRP kits that I had managed to amass over the last couple of years.

Wow! A chance to win a newcomer to the ranks of amateur radio! Why not? That started what has become in recent months Llyam's quest to become a ham radio operator. This is a good thing. I remember becoming interested in radio at around his age, shortly after my dad's console radio shocked the heck out of me. (Mom would say, "He's never been the same since.") That experience whetted my appetite and I just had to learn more about what "bit" me! Fifty-plus years later I am still learning, and it has been one heck of a ride. For Llyam to express interest in learning about radio and wanting to obtain his ham ticket is a real treat. A few more Llyams and I think our hobby has a chance to survive quite well!

Together we built one of Rex Harper, W1REX's "Tuna-Tin-II" transmitters for 40 meters. Llyam learned how to solder properly (he now corrects me when he sees me trying to cut corners with a soldering iron), how to read a basic schematic, how to understand resistor and capacitor codes, how to use a VOM's basic functions, how to wire a circuit, and how to perform the all-important "smoke test." It should be noted here that Llyam's first kit went together without a hitch (not counting putting the label on the tuna tin upside down, but that's a whole other story) and the "smoke test" went flawlessly. Listening to the milliwatt transmitter in a monitor receiver tuned to 40 meters (7040 kHz, to be exact) really excited him.

My 11-year-old grandson, Llyam, operating my Yaesu FT-726.

This was fully documented by my daughter, Maja, who took a ton of pictures, some of which ended up in the QRP book. Llyam, now world famous, is still full of questions and eager to learn more. A trip last year to the Military Radio Collector's Association (MRCA) meet at the West End Fairgrounds near Gilbert, PA, provided a chance for him to widen his radio horizons by being introduced to a different facet of the radio hobby: collecting, restoring, and using military electronics (primarily HF and VHF radio gear). The 30-plus attendees treated Llyam like royalty, and K1BOX gave him a PRC-10 (low-band VHF/FM man-pack radio set) to restore! Of course the real reason I brought him along was to crank the hand generator for the GRC-9! Nothing like a 10-year-old with lots of energy!

By now I suppose you are wondering what all this has to do with VHF-plus. In his quest for his license, Llyam has dutifully been studying the question pool, using his flash cards, asking endless questions, and having very little fun in the process. Unfortunately, today's kids need a lot of instantaneous feedback to maintain their interest in a project. It is

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Llyam on the roof holding on to the mast that supports the loop antennas.

the same with Llyam. He needs some "hands-on" to keep his interests kindled and burning brightly. Enter the September VHF QSO Party the weekend of the 13–14, 2008.

In the early 1990s I purchased a Yaesu FT-726 tri-band VHF/UHF transceiver from Rick Rinehimer, K3TOW. I used this radio quite successfully for some terrestrial weak-signal work along with some Low Earth Orbit (LEO) Mode-A satellite work. Mode-A, for those who don't remember, entailed transmitting uplink to the satellite on 2 meters and receiving the downlink on 10 meters. It is sort of a flying cross-band repeater system. Unfortunately, I had to sell that rig (something about a house payment, or food, or bills, or some other such nonsense) about 1996, and I have regretted that decision ever since.

About two months ago I found another FT-726 on eBay for a reasonable price, so I jumped at the chance to procure this radio set. It came with only the 2-meter and 70-cm modules included, but that was enough for the present. Llyam, of course, noted a new piece of gear in the shack about 3.2 microseconds after he arrived, so we had to give a demonstration.

Living inside the city limits of Wilkes-Barre, Pennsylvania, which is down in a valley (the Wyoming Valley, actually), is a severe drawback when it comes to VHF-plus operating. Aside from the obvious problems with line of sight (LOS) transmission and reception paths, running some medium to high power on the high bands can quickly bring your station to the attention of your neighbors. Having been in our present home for 20 years, my neighbors pretty well knew that I was crazy, putting up all sorts of antennas during various times of the year. Running QRP on HF kept me out of their TVs, stereos, toasters, and electric toothbrushes. However, a QRP power level of 5 watts output on VHF plus without some serious effort to erect some killer antennas is really counterproductive. While the LEO satellites were great fun, serious terrestrial weak-signal work was very limited at my present location.

Enter "Mr. Enthusiasm," aka Llyam! To an 11-year-old aspiring radio amateur nothing—and I do mean nothing—seems impossible. It's so nice to be young! I let slip the information about the September VHF QSO Party in a couple of days and Llyam jumped at the idea of "working the contest." I tried to explain that while we had the transceiver to do the job, antennas were critical and I really didn't have anything up for the VHF bands except for the Diamond discone that was shared between my 2-meter FM rig and my scanner. Not to be daunted, Llyam reminded me of the three halo antennas I had sitting on the porch that were supposed to be going up at our new home in Dacula, Georgia.

OK, we'll see what we can kluge up in a couple of hours. The halos were the work of Phil Brazzlle at the KU4AB antenna lab in Collierville, Tennessee (http://ku4ab.com/). I had read the e-ham reviews of these inexpensive halo designs along with testing and gain results at the Central States VHF Society's website (http://www.csvhfs.org/). I ordered one halo for each of my favorite VHF-plus bands—6 meters, 2 meters, and 70 cm—with the idea that I would add a second halo for each of the three bands, along with the phasing kits after settling in at our new place in Georgia.

Halos in hand, Llyam and I found a 10-foot piece of steel mast to support the three antennas along with three runs of RG-213 coaxial cable, complete with connectors installed. Hey, this would be a quick and dirty antenna installation that couldn't get much easier, could it? (I know what you're thinking: I have just violated the prime rule of amateur radio antenna parties, thereby upsetting Edsel Murphy!)

Up on our flat roof above our dining room, Llyam and I took down the old, trusty Diamond discone that had been up there for about six years. Although I had used that antenna for 6- and 2-meter activity, it was low to the ground and I wanted to get these new antennas a bit higher for possibly better results.

We positioned the antennas on the 10-foot steel pole starting with the 70-cm halo at the very top. Coming down about 24 inches, we placed the 2-meter halo, and coming farther down the mast about 60 inches, we placed the 6-meter halo. We had sort of a weird-looking VHF-plus Christmas tree made from halo antennas and a steel mast! Who says life doesn't imitate art?

Llyam helped me install the RG-213 coaxial cable on each antenna, tape the connectors, and then tape the coax down to the mast to provide a neat installation. Once we had everything put together and tied down, I placed the "short stack" on the mast that originally held the discone and we were done, except for running the coaxial cable into the shack. We exited the roof, assembled in the make-shift shack (the main shack was completely torn down pending our move) consisting of a computer table and a FT-726 transceiver. After retrieving the coax and running them to the radios, we then set about checking out things using my MFJ Model 269 Antenna Analyzer. Now for those of you who don't have one, my best advice is to get one—*now*! Seriously, this analyzer can be the best, most relied upon piece of antenna test gear you will ever own. The 269 covers from the lower HF bands up through 70 cm. It's a really nice piece

CQ's 6 Meter WAZ Awards

(As of October 1, 2008)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2.40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28.29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	K0SQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,2,12,18,19,32
85	K4PI	17,18,19,21,22,23,24,26,28,29,30,34,37,38,39

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of test gear that once you have one, you'll wonder how you ever got along with out one! (No, I don't have an affiliation with the company, just a very satisfied user).

While the 6-meter and the 70-cm halos performed as advertised with their center frequencies almost spot on according to the factory numbers, the 2-meter halo had some "issues." It seems that either there was a problem with the coaxial cable, one of the end connectors (although we had ohmed them out prior to installing them), or the antenna itself, as I could not get it to resonate anywhere near the 2-meter band! Edsel? Oh, there you are! Well, nothing to do but hit the roof again.

Back on the roof, Llyam and I pulled down the "short stack" and removed the tape around the connector. About that time Llyam ask me about the funny little wire sticking up in the air at the feedpoint of the antenna. Hmmm . . . it looked like possibly a cold solder joint at the factory. The center conductor connection from the SO-239 coaxial connector to the antenna had popped loose and was hanging in mid-air. No wonder I couldn't get a proper reading on the analyzer. We quickly took off the 2-meter halo, returned to the house, re-soldered the errant wire, and proceeded to put the antenna back on the mast and replace the mast on the roof. All of this totaled about 30 minutes work. Now 2 meters worked fine. Unfortunately, though, Murphy wasn't quite through with us yet!

We fired up the FT-817 on 6 meters and worked a couple of locals calling "CQ Contest." It was Llyam's first attempt at contesting, so we had to coach him a bit, but he soon became quite adept at calling stations and giving the exchange. Going to 2 meters on the FT-726 yielded a few more stations, including several we had worked on 6 meters. Again Llyam was eager to get into the fray. Finally, migrating up to 70 cm we found another problem. The connector on the 70-cm antenna had a bad PL-259 on the shack end, which initially we had neglected to spot. Out came the 100W iron, solder, X-Acto™ knives, and the small pipe tubing cutter, and I showed Llyam how to properly install a PL-259 on a piece of coaxial cable.

Once we had replaced the connector we were good to go on 70 cm. There we worked only a couple of stations, but nonetheless, Llyam was intrigued by the magic of ham radio.

How did we do in the contest? Probably dead last, but who cares? This wasn't a serious contesting effort, but it was a serious attempt to give a fledgling radio amateur some insight into a different facet of the hobby. Since Llyam's first license will be Technician Class, knowing that lots of fun can be had on the VHF/UHF bands without a major outlay of money will keep him interested. Not only did Llyam get a chance to rub elbows with some of the local "big gun" contesters in this area, he got a feel for contesting without all the hype and craziness associated with a major contest effort. Additionally, we had some valuable lessons in troubleshooting, learning how to install connectors, proper use of a VOM and an antenna analyzer, and some critical thinking skills used in troubleshooting. These are the kind of things that the books and flash cards can't teach a person. It takes some one-on-one a lot of times to get through some of the theory of radio.

How is Llyam after his first contesting effort? Back in school, doing homework, and studying his ham test questions. He'll be ready for the test. Then he'll have bragging rights at school. After all, how many fifth graders can talk about satellites, work the world, or build a radio? Not too many, and I am positive of that! ■

Radio Life Insurance with "SPOT"

Your spouse tracks your 10-GHz rover operation on the internet, and as you step back to admire your massive mountaintop X-band system a diamondback rattler sinks its fangs into your left ankle. No cell phone coverage, so you push the SPOT satellite transponder "911" button and the rescue begins.

By Gordon West,* WB6NOA

If you are into VHF/UHF and microwave roving, there is a new, inexpensive satellite transponder system that might save your life. It will also keep your XYL back at home taking part in your adventure. She can track your progress going up the hills with Google Maps® showing your precise location. I wish this was on ham radio APRS, but no such luck. Nor is this commercial system an EPIRB (Emergency Position Indicating Radio Beacon) or a (PLB) Personal Locator Beacon.

This small satellite transponder, called "SPOT," is a product of Globalstar USA, a Vodaphone Airtouch Pic company best known for those classic-looking satellite phones that many ham radio emergency responders used during the Katrina crisis along with the reliable ham radio communications gear.

This small orange transponder has plenty going for your safety when you head out on your next VHF/UHF rover expedition. The SPOT device itself sells for under $150, plus there is a basic service charge for a one-year contract that is $99 per year. Add $7.95 to include $100,000 last-resort evacuation service, and add $50 if you regularly go hiking and you want your SPOT unit to *automatically* update your position every few minutes or miles, independent of cellphone coverage.

The seven-ounce SPOT portable position sender contains a built-in GPS receiver tied into the L-band transmitter, tuned to commercial Globalstar LEO satellites, 1611 MHz to 1618 MHz, digital code division multiple access (CDMA), running about a quarter watt out. Two lithium-ion AA batteries could allow for 1900 uplinks, or when key-entered into the automatic tracking mode, 14 days of continuous operation.

An Emergency Position Indicating Radio Beacon (EPIRB), left, and the orange SPOT distress signaling device side by side on a marine chart. (Photo by Julian Frost)

The orange SPOT satellite transponder floats in water, is waterproof up to 1 meter down for 30 minutes, carries military standard 810 E method 507.3, withstanding 100% condensation, and is shock resistant.

To conserve battery life, the GPS receiver built into the SPOT unit only powers on to retrieve a current position fix needed for a manual or automatic uplink to the chain of 48 LEO (Low Earth Orbit) Globalstar satellites. As long as the satellites have a mutual view of their associated ground Earth stations and the SPOT unit, the position goes onto the internet, along with the status of the SPOT transponder's operator, such as:

- I'm OK; all is well.
- I could use some help (non-emergency).
- Dispatch emergency responders to this location *now*.

OK, as a ham operator well versed in satellite communications, you can quickly see that the SPOT device is an L-band one-way transponder, sending latitude and longitude and one of three messages, and has the capability for all this information to stream into the internet.

You can buy a SPOT transponder at your local West Marine store or at a major camping store. Your registration, to acti-

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Several hams from Alaska, as well as some from the "lower 48," attended a recent hamfest and got a chance to see the High Frequency Active Auroral Research Program (HAARP) massive antenna array in Gakona, Alaska. For more information about the HAARP program, see :<http://www.haarp.alaska.edu>. (Photo courtesy of the author)

vate the service, is at: <http://www.findmespot.com>. You will need to provide the electronic serial numbers found in the battery compartment of your new "radio life insurance" package.

The secure site will take your credit card when you sign up for the $99 basic service. Be sure to add the $7.95 yearly fee for the $100,000 private rescue service in case there is no local public search-and-rescue service in the area of your emergency.

First, select a reliable phone number to verify any emergency alert. Next, provide up to 10 e-mail addresses for your friends and family members to receive your messages. You can even put down cellular, short messaging-service numbers, too. You may change any of these e-mail address at any time, at no additional cost.

If you get in a jam with your roving operation, you have up to 10 additional "HELP" e-mail options. This could include your next-door neighbor who has a 4-wheel drive "yank" truck, or ham friends who might get on the air to arrange a help party, or other resources, other than your family and friends, who should get only the "I'm OK" message, not the "need some help" message. Plan your "I need help" e-mail posting cautiously so you don't end up with three towing companies coming on the scene when you only need one. I only have one "help" person listed in my e-mail to avoid the activation of too many resources.

If you sign up for that extra $50 "SPOTCASTING" tracking service, it will send out an "I'm OK" to your family and friends and a numerical track of your progress, like a breadcrumb trail, on Google Maps®!

As a last resort, such as a snake bite at a desolate location, push the 911 button and that will direct an immediate e-mail to Globalstar's emergency rescue facility, GEOS, located in Texas. GEOS offers an entire world of government, county, city, and private emergency services for an immediate response to a SPOT 911 call. If you signal for help on a mountaintop, GEOS will first call your "verify that I'm out with SPOT" phone number to authenticate that you are really out there in radio land doing your ham radio thing. Once they know that this is likely a for-sure distress call, GEOS looks at your coordinates, overlays an emergency response map, and passes your distress information to a local agency to respond to the call for help within their jurisdiction. Up in the mountains, it most likely would be a direct call to the forest service or a ranger station. If the distress call comes from a local city jurisdiction, they call that city's "back door" phone number to their 911 center.

Most of my microwave work takes place in rare ocean grid squares offshore, and if I sent out a 911 call on my SPOT unit, the call would go to our local US Coast Guard station, or if far out at sea, to the US Coast Guard Rescue Coordination Center. The US Coast Guard, according to Kathryn Niles, Office of Search and Rescue, would likely take the same appropriate speed and action as if this call originally emanated from a marine Emergency Position Indicating Radio Beacon. However, just like any EPIRB response, the US Coast Guard would want just as much authentication that this is a real call, rather than an accidental activation on shore. Therefore, if your spouse picks up the phone and confirms to GEOS that you are indeed out on a boat 100 miles offshore, this 911 call would be treated with the same speed and resources as any other type of distress call.

This need for confirmation is why it is vitally important to list several phone numbers on your sign-up application to find someone at home, and someone who is familiar with your ham radio roving activities to verify you may be out in the boondocks. Make certain your phone number reflects someone who has a clue as to where you might be with this little orange transponder!

"When the 911 button is pressed on a SPOT satellite messenger, the distress signal is immediately sent to GEOS, the international response center used by SPOT. This 911 message is position-updated every 5 minutes, providing information if someone is in the water in a current or trying to self-rescue and on the move. The only time the 911 button should be used is in a true life-and-death emergency," comments Derek Moore, SPOT Satellite Manager.

SPOT works from Alaska to South America, throughout all of the United States, and covers much of Europe. See the up-to-date coverage map at: <http://findmespot.com/exploreSPOT/coverage.aspx>.

A satellite ground station located in Wasilla, Alaska had me covered during a recent Alaska hamfest and associated radio operating events at the Arctic Circle. We were well beyond cellular coverage. Nevertheless, it was fun to automatically squawk our position and "I'm OK" updates to my internet friends, knowing we were just a pushbutton away from help if something went terribly wrong in the far north.

Yes, ham radio HF might be used in an emergency, but it's tough in Alaska getting a signal out on HF through the constant aurora. APRS satellite updates might indeed be another way to go, but the SPOT commercial unit would the easiest choice in an emergency.

Therefore, add SPOT as part of your communications resources. Not for a second am I discounting all of the capabilities we have as ham radio operators to send third-party traffic home, and to get help when required. However, for a couple of hundred dollars initial investment, plus a hundred bucks a year service fee thereafter, the Globalstar SPOT program makes good sense for reassuring your family and friends by e-mail that you are "OK" as you do your ham radio roving nearly anywhere in the world. It's great for some added radio life insurance when you're "out there" beyond local cellphone coverage. ■

Tulsa (OK) Technology Center's Innovative Approach to Training Future Engineers

This past spring KE5URH and his students at the Tulsa Technology Center designed and built balloon sats for launch by Oklahoma State University's ASTRO balloon-launch program. Here he discusses his technical and development journey from development of the balloon sats to their launch.

By Doug Benton,* KE5URH

Over the past few years there has much concern has been voiced over the dwindling number of engineers and high-tech technicians in this country. Many of us believe that the roots of this dilemma are found at the high school level. Whether it is because of a lack in preparation or a lack of interest, our young adults are not competing in the engineering curriculums at our country's major research universities.

Various national initiatives have been under way for the past two decades to recruit and develop aspiring young pre-engineers at the high school level, with the hope of refreshing our aging high-tech work force. Recently, these initiatives are being taken more seriously due to increased indications that the United States is losing its role as the world's leader in innovation and technology. Here in Tulsa, Oklahoma, bridges are being built to span the academic gap between our teenage talent and our engineering colleges.

Under the mentorship of Professor Andy Arena, KE5CAB, and PhD candidate Joe Conner, W2OSU, both of Oklahoma State University (OSU), as well as Mr. Harry Mueller, KC5TRB, of Oklahoma Research Balloons, Tulsa Technology Center's "Introduction to Aerospace Engineering" class built payloads to fly on OSU's ASTRO-08 balloon-sat mission, which was successfully flown on February 22, 2008.

The mission objective was to carry student payloads and experiments to the near-space altitude of 100,000 feet MSL, to track and recover the payloads, and then to download and process the data. Student payloads consisted of cameras and temperature data-acquisition equipment. The experimental payloads, built by Joe Conner, consisted of two video cameras, with a third experiment to test a Dual-Tone Multi-Frequency (DTMF) activated cut-down device. This article will focus primarily on the educational aspects of this project, from the perspective of the Tulsa Tech students and their instructor, your author.

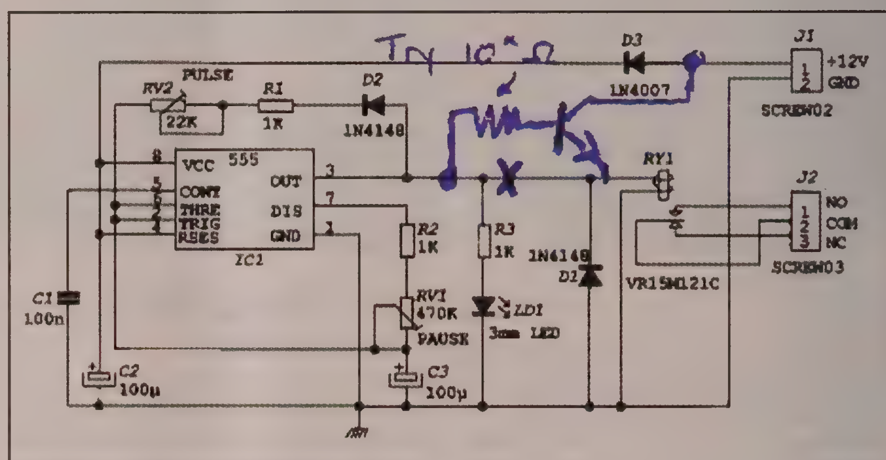

Figure 1. Velleman's MK111 Interval Timer kit modified circuit. Modification courtesy of Barry Lazzer, Tulsa Technology Center's Digital Electronics instructor.

Because this type of course work and activity is new in Oklahoma at the high school level, many technological and logistical details needed to be ironed out. All the normal challenges associated with a start-up program were encountered this year. For this mission, I, the instructor, and the students set modest goals. Many lessons were learned through trial and error, and as wisdom would dictate, we learned far more through our failures than we ever could have if everything worked the right first time.

The class objectives for the payloads were to develop reliable and inexpensive technologies for: (1) photographing the Earth at near-space altitudes; (2) gathering atmospheric data; and (3) processing Automatic Position Reporting System (APRS) packets and tracking the payload. Objectives 1 and 2 were reasonably successful, while objective 3 needs further development within the Tulsa Tech class.

Camera Circuit

Based on feedback from multiple sources, we chose the adjustable Interval Timer kit, manufactured by Velleman, to trigger an Aiptek PocketCam on a 20- to 30-second cycle. We found the timer kits easy to assemble, convenient for school purchasing, and inexpensive. At room temperatures the 12-volt kits worked fine. However, we had problems with our kits when they were exposed to even

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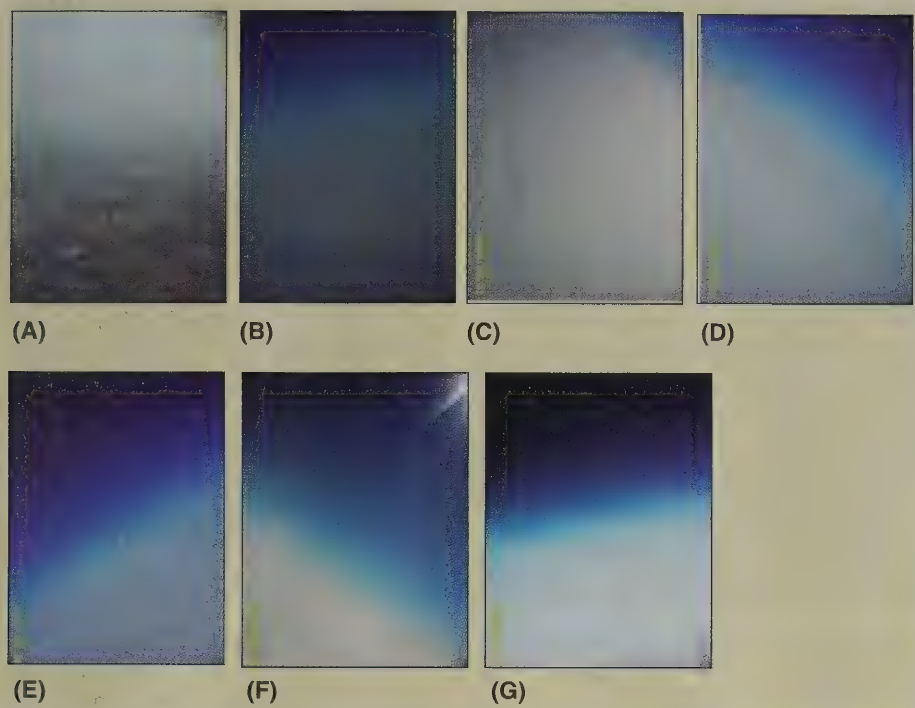

Photos 1A–G. Selected ASTRO-08 mission student photos: (A) approximate altitude 1,900 feet (view of OSU's new stadium); (B) approximate altitude 7,500 feet; (C) approx. alt. 13,500 feet; (D) approx. alt. 18,000 feet; (E) approx. alt. 27,000 feet; (F) approx. alt. 32,600 feet; (G) approx. alt. 99,000 feet.

moderate drops in temperature. Specifically, while at room temperature the timer kit was set for a 1-second pulse and a 30-second pause. Then after the temperature dropped to around zero degrees Celsius, the pulse would extend to over 2 minutes with the pause remaining at the original 30 seconds. This drastic increase in the cycle time would, in turn, cause the cameras to go into sleep mode prematurely and cause battery life to decrease.

A fix was incorporated by placing a transistor on the output pin of the 555 timing chip to drive the relay (see figure 1). With this change in place, the timer kit functioned properly at and below zero degrees Celsius. I observed this modified circuit working fine for over an hour in a freezer without insulation or supplemental heat. Next year's class will use a different, smaller timing circuit. A transistor will be used to switch the camera's trigger, as opposed to a relay switching the camera's trigger.

The PocketCams were inexpensive enough, costing approximately $30 each. They are lightweight and were easy enough to integrate with the timing circuit. The resolution of the photos taken at altitude was acceptable given the extreme temperatures and the low cost. However, two out of the three student payloads' cameras quit taking pictures early during the flight. We have multiple theories as to why the cameras malfunctioned, and it will fall to the next year's class to resolve this problem.

Photos 1A–G were taken at random intervals on the flight up. The atmosphere was very cloudy, resulting in unimpressive photos for this mission. Notice that we need to turn the date-time-stamp off for the next mission, and we need to turn our cameras 90 degrees to the landscape orientation.

Heater Circuit and Temp Data

The Hobo Data Logger, by Onset Computers, was used to gather temperature information for the mission. This is a great device. It is lightweight, easy to use, and collects temperature and relative-humidity data. The price is moderate at approximately $130, with another $25 going towards software. We developed a simple and lightweight thermostat circuit (photo 2) to latch-on the "heaters" (two power resistors) at a preset temperature. The thermostat and heater circuits with the 9-volt battery had a combined weight of 67 grams.

This heater circuit in conjunction with the data loggers will continue to be a nice educational resource. The students will be exposed to more electronics as they build the circuits, and they will be able to collect data on their experiments related to the satellite's thermal conditions during flight. The thermostat will allow the students some flexibility in choosing the start conditions for the satellite's heater.

Because this was the first mission for the Tulsa Tech class, temperature data was collected on the interiors of the satellite boxes, as opposed to collecting the atmospheric temperature data. We were more concerned about the adequacy of our small heaters. Figure 2 is a chart of the temperature data collected on the inside of one of the satellite boxes. You can see that the heater circuit turned on at 18 degrees F, approximately 15 minutes before apogee.

We believe the 5-degree shift in temperature produced by a single battery and two small resistors is adequate for our purposes. Again, our goal is to keep things cheap and lightweight. Note that the elevated temperatures from 15:00 hours to 18:00 hours on the horizontal line are due to the box being stored with a hand warmer accidentally enclosed in the box. A possible improvement for next year's class would be incorporating in the circuit a large amount of hysteresis to turn off the heater when the temperature reaches a level 20 degrees higher than the trigger temperature.

Tracking System

Joe Conner, W2OSU, built the tracking module for this mission, which consisted of three independent tracking systems. The first system, transmitting on 144.360 MHz, used a Kenwood TH-D7A to transmit APRS packets containing position information generated by a Garmin GPS 18. The second tracking system, transmitting packets on 144.390 MHz, used a PocketTracker to transmit information generated by a second Garmin GPS 18. The third system, transmitting CW ID beacons on 147.475 MHz, was a K12 CW Beacon Kit fabricated by Harry Mueller, KC5TRB. All three systems were used in previous ASTRO missions and were already proven reliable. Both Joe Conner and I used mapping software to track the satellite positions on a

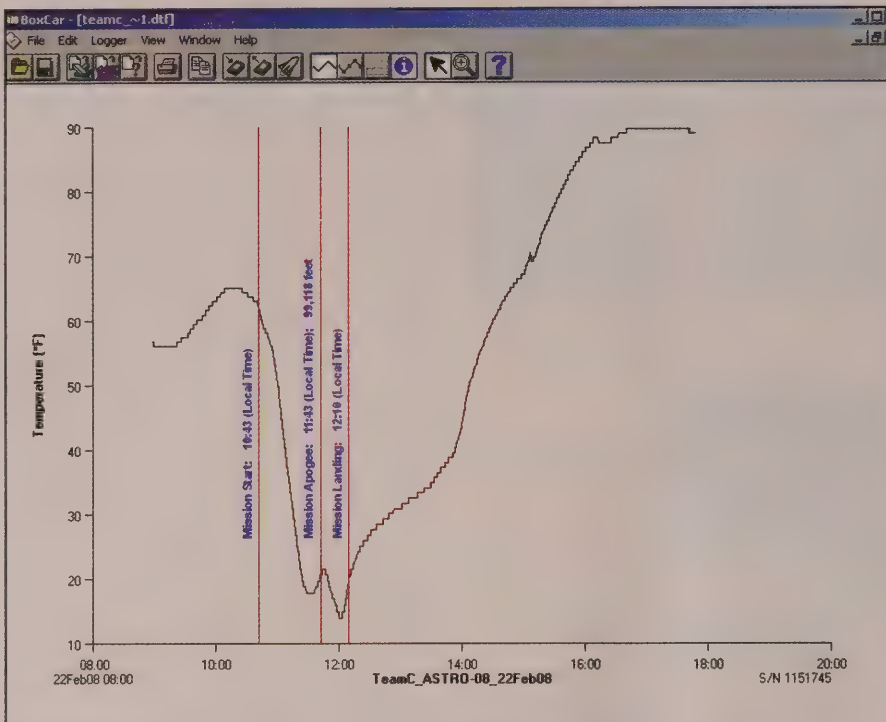

Figure 2. Temperature profile of box interior.

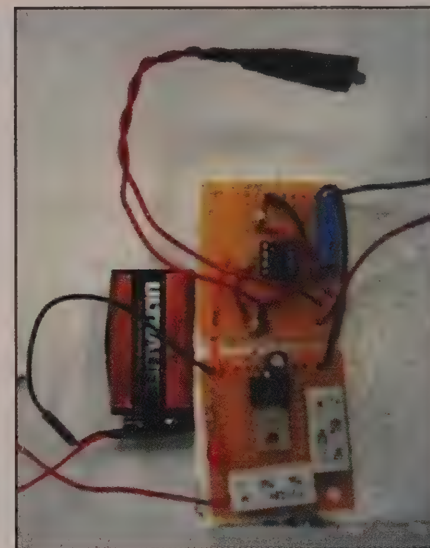

Photo 2. Thermostat and heater circuits. A 741 op-amp is set up as a comparator, which triggers a silicon-controlled rectifier (SCR). The SCR "latches on" the heater circuit. The 9-volt battery is drained through the two resistors (5watt, 5 ohm).

laptop in real-time. I have a goal of building these tracking systems and incorporating them into the class learning activities in the near future.

Educational Benefits

Realistic problem-solving is the one aspect of Project-Based Learning that truly prepares a student for life's challenges. No one would probably question that assertion. However, the problem for us educators is choosing projects that are: (1) skill-level appropriate for the student; (2) skill-level appropriate for the instructor; (3) feasible within the school's budget; and (4) logistically feasible based on factors local to the school (i.e., geography, transportation, and FAA-controlled airspace).

Various aspects of the balloon-sat project are skill-appropriate for a high school junior or senior, provided some prerequisite skills are addressed. The student must be able to solder and read simple electronic schematics before starting the project. Most likely, the high school student should not be expected to make decisions concerning most electronics—at least not at the start of the school year. All aspects of this project need to be well organized and thoroughly communicated before handing it over to the teenage student.

Certain sub-systems need to be taught pedagogically in order to develop a good intellectual foundation for the students. In the early part of next year's class, it is my intention that the students will build, step-by-step, an astable 555 circuit (oscillator), a mono-stable 555 circuit, and a thermostat circuit—all in a pedagogical manner, in order to build a quick foundation in analog electronics. Later, they will be shown how to integrate these circuits. As for telemetry, possibly future classes will build something similar to the TinyTrak kit. However, for the near term, until the instructor acquires a ham license and gains more confidence in using the tracking technology, construction of the

Photo 3. OSU Professor Dr. Andy Arena surrounded by student assistants inflating the sounding balloon.

tracking systems will not be a major part of the in-class learning activities.

The skill-level of the instructor is an important aspect of this project's educational effectiveness. The instructor needs some background in electronics and amateur radio technology to make this project a success. In general, most high school students need a high level of structure to be successful in building these electronics projects.

Only when the instructor has a solid foundation in electronics can this structure be provided to the average teenage student. Otherwise, even the above-average student will lose motivation and then class discipline tends to become an issue. In addition, adult decisions need to be made concerning FAA regulations. This all requires mature supervision, sound engineering judgment, and good shop organization.

The school's budget will also determine whether this project gets off the ground. For one student satellite box with a Aiptek PocketCam, a Hobo Data Logger, and a small heating circuit, the cost was approximately $230, with another $200 of soldering supplies. If three students work on one box, then we arrive at approximately $145 per student per satellite box per year. Additional items include a 1500-gram balloon (Kaymont ~$95); radios (e.g., Kenwood ~$325); antennas (~$50); and lithium batteries (~$50). A rough estimate for four satellite boxes, balloon, tracking equipment, and miscellaneous supplies is approximately $1500 for the first year and $500 each year thereafter.

Lastly, there will be a myriad of external factors that may affect local decisions. Some other considerations might be:

- Geography—western and central Oklahoma are great places to recover weather balloons due to the lack of trees and people.
- Transportation—the fewer the number of students to transport to the launch and recovery sites, the simpler transportation becomes.
- FAA Controlled Airspace—the launch and recovery sites should not be located near busy airports.
- Available Mentors—if a large number of students are involved with launch and recovery, the instructor will need assistance supervising the teenage students.

As interest increases in the Introduction to Aerospace Engineering courses at Tulsa Tech, all of these logistical challenges will increase. It remains to be determined how next year's 32 students will all participate in launching and tracking one or two balloon-sat missions.

Photo 4. The launch crew enjoying the view of their first mission launch.

Summary

Incorporating high-tech, challenging projects into the high school environment is difficult. We want to stretch the students without breaking their motivation. We want to push them to acquire deeper math, science, and engineering skills so they can do well in their early college years. However, we don't want to push them away from the hard sciences either. It's a tough balancing act.

Added to the mix are teens behaving like adolescents and a market pulling well-trained technical professionals away from the classroom. Most high schools are not equipped to handle the more in-depth technical projects. Fortunately, Oklahoma has a well-developed CareerTech system that has made a commitment to the pre-engineering curriculum. Many of Oklahoma's Technology Centers are in a strong position to fund these projects and to hire instructors with the appropriate experience to lead them.

Genuine problem-solving skills were necessary for the completion of this project. The mistakes made in the course of this first balloon-sat project at Tulsa Tech were priceless. Both the students and I were forced to adapt and overcome technical difficulties. In the end, this project was a great example of what Project-Based Learning should look like. In our next phase at Tulsa Tech we will turn our sights toward organizing this project and making it accessible to a broader scope of students, with the hope of challenging the next generation of engineers.

Equally important to our project-based learning efforts is mentorship by our community's professionals. For this project we had help from key individuals associated with Oklahoma State University, Oklahoma Space Grant Consortium, Oklahoma Research Balloons, *CQ VHF* magazine, and other Tulsa Technology Center instructors (Barry Lazzer and Jim Snow). The message is out; our community's engineers are getting involved with raising-up new engineering talent. These types of practical relationships are critical for incorporating challenging projects at the high school level. The question is: Do we have enough of these processes in place to grow enough engineers in the next decade? ■

Links

http://www.kenwoodusa.com/Communications/Amateur_Radio/Portables/TH-D7A(G)
https://buy.garmin.com/shop/shop.do?cID=139&pID=6445
http://www.byonics.com/pockettracker/
http://members.cox.net/hhm_74665/orb/k12/
http://www.byonics.com/
http://www.kaymont.com/pages/home.cfm

Contact: Another First (On Earth)

A growing number of school teachers are finding creative ways to use amateur radio in the classroom as a learning tool. Here VE3NCE describes how he used amateur radio to teach about archeology, as well as expose his students to the benefits of amateur radio communications.

By Neil Carleton,* VE3NCE

"V-E-3-B-S-B at Murphys Point Provincial Park, this is V-E-3-N-C-E in room 24 at R. Tait McKenzie Public School in Almonte."

With this first call, my Grade 5 students stirred with excitement at their desks as we launched our on-air connection with an archaeological site on the other side of Lanark County in eastern Ontario. It was the start of two successful contacts in which amateur radio linked the students in the classroom with archaeologists in the field at the Hogg Bay excavation site, near the town of Perth. This was a first in Canada—to have elementary students in the classroom connected by amateur radio with archaeologists at an excavation site.

As part of our Grade 5 social studies program, my students and I visited Murphys Point Provincial Park on October 2, 2007 to take part in a real archaeological dig. Details about this remarkable full-day program for Grade 5 classes are available at the website of the Friends of Murphys Point Park: <http://www.friendsofmurphyspoint.ca>; click at the top of the page on "The Hogg Bay Dig," or click at the left on "Project" and then "Hogg Bay Project."

My Grade 5 students, and the parent volunteers who helped out, said our visit to Murphys Point Park and the opportunity to take part in a real archaeological dig was the best field trip ever. Our two amateur radio contacts with the site archaeologists made it just that much better.

On Monday, October 1, the day before our field trip, half of the class had their questions about archaeology answered on the air by the archaeologists at the Hogg Bay site. As a follow-up to the visit, the other half of the class spoke via amateur radio with an archaeologist on Thursday, October 4, about their field trip observations and the things they learned.

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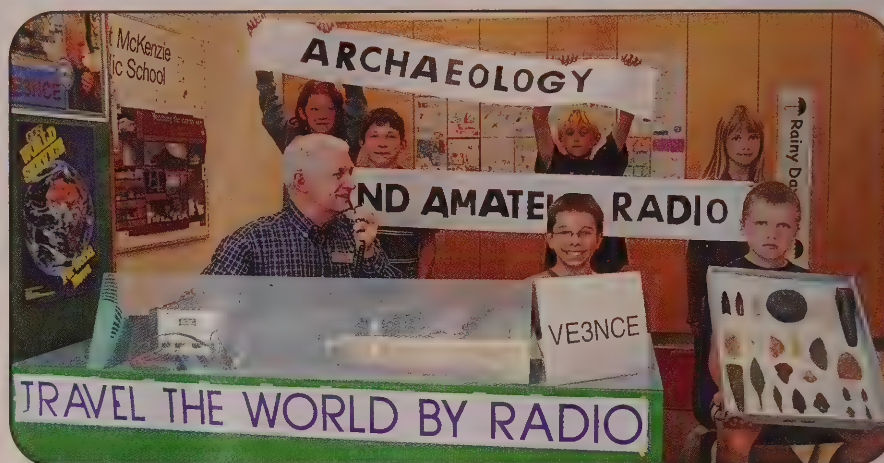
This article first appeared in the March/April 2007 issue of The Canadian Amateur *magazine. It appears by permission of Radio Amateurs of Canada and the author.*



Grade 5 teacher Neil Carleton, VE3NCE, and his students in room 24 at R. Tait McKenzie Public School, in Almonte, spoke via amateur radio with archaeologists at Murphys Point Provincial Park. (Photo by Jennifer Eldridge, Almonte Gazette)

These two special contacts were made with my classroom VHF amateur radio station. We sent our signals from the school to a repeater station on a communications tower at Lavant, about 40 kilometres to the northwest. Our voices were retransmitted by the repeater station at Lavant (VE3KGJ, 146.640 MHz) and heard at Murphys Point Park, as well as other locations across the region. The answers to the students' questions were transmitted from temporary stations set up at the excavation site, and the examination location in the park, by volunteers of the Lanark North Leeds Amateur Radio Emergency Service (LNLARES).

The student voices from room 24 were also heard across eastern Ontario through three other repeater stations that are linked to the Lavant site at Christie Lake (VA3TEL, 145.230 MHz), Tweed (VE3RNU, 145.370 MHz), and Toledo (VE3HTN, 46.865 MHz). The coverage area of the four repeater stations extends from Stittsville to the east and south to Morrisburg on the St. Lawrence River, west to Picton in Prince Edward County, up to Havelock in the northwest, and over to Renfrew in the north. Listeners in New York State south of Brockville on the St. Lawrence River were also able to hear the students at R. Tait McKenzie talking with the site archaeologists at Murphys Point Park.

A dedicated group of very helpful and kind volunteers in the Perth area, from the LNLARES, were our community partners at the park for these special contacts. The radio operators on site for our contacts were Barrie Crampton, VE3BSB, Al Niittymaa, VA3KAI, and Tony Wilson, VE3XNT. George Ward, VE3GXW, was on hand to take photos on both days. Many thanks to the generous volunteers of the LNLARES group for making the radio component of our archaeological adventures such a success.

Special thanks as well to archaeologists Jeff Earl and Brenda Kennett for taking part in our unique amateur radio contacts. Your adventurous spirit and enthusiasm for the project were appreciated very much.

LNLARES volunteers Al Niittymaa, VA3KAI (left), and Barrie Crampton, VE3BSB (right), listen as archaeologists Jeff Earl and Brenda Kennett answer student questions from the classroom via amateur radio at the Hogg Bay excavation site at Murphys Point Provincial Park. (Photo by George Ward, VE3GXW)

For our contact, on Monday, October 1, the LNLARES volunteers set up one station at the excavation site and a second station at the examination location. An archaeologist at each station took turns answering the questions from R. Tait McKenzie students.

Our second contact, on Thursday, October 4, was during the Media Day activities at the site with sponsors, supporters, school board representatives, and media reporters in attendance. Only one amateur station was needed at the park that day, at the examination location, because the busy site schedule prevented both archaeologists from taking part.

I recorded both contacts to create a transcript of the student questions from the classroom and the replies from the archaeological site. As a surprise holiday gift before the December break, each student in my class received a CD with the transcript of our contacts and a selection of photos from the field trip.

R. Tait McKenzie is a participating school in the national Youth Education Program (YEP) of Radio Amateurs of Canada. Supported by Canadian astronaut Dr. Robert Thirsk, VA3CSA, the program was created to encourage the use of amateur radio at schools across the country. Details are available on the RAC website at <http://www.rac.ca/YEP/>.

I use amateur radio each year at school to bring the world, and space, into my classrooms. Thanks to amateur radio, contacts with archaeologists, astronauts, and Antarctic researchers have enriched the learning of students at our school.

You can read about some of the radio projects here at R. Tait McKenzie Public School on the website of *The Canadian Teacher* magazine; at <http://www.canadianteachermagazine.com>, click at the left on "Back Issues," then click on "Fall 2006" and scroll down to page 8.

The amateur radio program in my classroom is supported by volunteers from the Almonte Amateur Radio Club (AARC) through their generous donation each year of time, expertise, and equipment. Under the leadership of Bob Clermont, VE3AKV, AARC volunteers have helped in so many ways for students at R. Tait McKenzie to talk with radio amateurs around the world, and in orbit, as part of their learning at school.

If your amateur radio club hasn't considered it yet, I encourage you to think about adopting a school so amateur radio can be used to reach out and bring the world into a local classroom in your community, too. ■

By Miguel Enriquez, KD7RPP

ATV

Amateur Television for Fun and Education

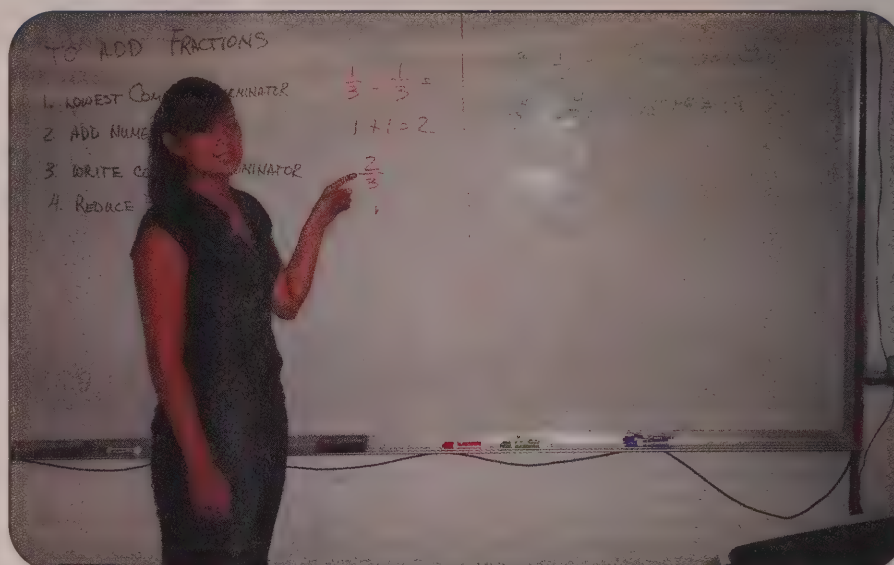
Thanks to ATV, Parents Can View Their Children Teaching Math on the Internet

Putting amateur radio to work and demonstrating the benefits it provides to mankind has been confirmed countless times since day one of our hobby. Amateur radio operators in near and far-away places rising to assist or save folks in peril make the news reports quite frequently. However, we hardly ever hear of the skills and dedication required to make that particular rescue possible. Therefore, we go about our lives, safer and happier because of ham radio, not fully appreciating the full impact that amateur radio has on us all.

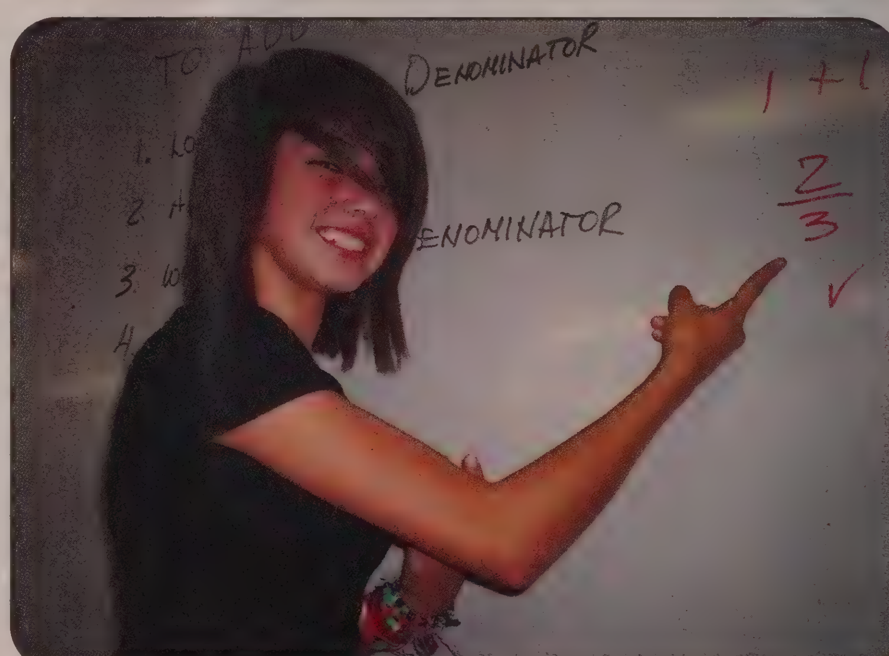
Amateur Television, on the other hand, does not suffer this same degree of indignity. It suffers an even greater level of indifference. This is because few people, including some ham radio operators, tend to view ATV as capable of delivering little in terms of community services. Sure, we televise picnics and gatherings, bicycle events, local parades, and even the Rose Bowl Parade many years ago. However, it is the opinion of this author that ATV has been allowed to sink to a low level of importance, not because of its limited capabilities but because only a few ham operators are actively participating in its development.

Perhaps those days are coming to an end. In trying to figure out a way to put our own ATV resources to better use, the students in the Pueblo Magnet High School Amateur Radio Club are embarking on a new venture—the delivery of math instruction to elementary schools via ATV and the internet.

Pueblo ARC students are busy preparing 3–5-minute vignettes that will be aired live to any classroom wishing to

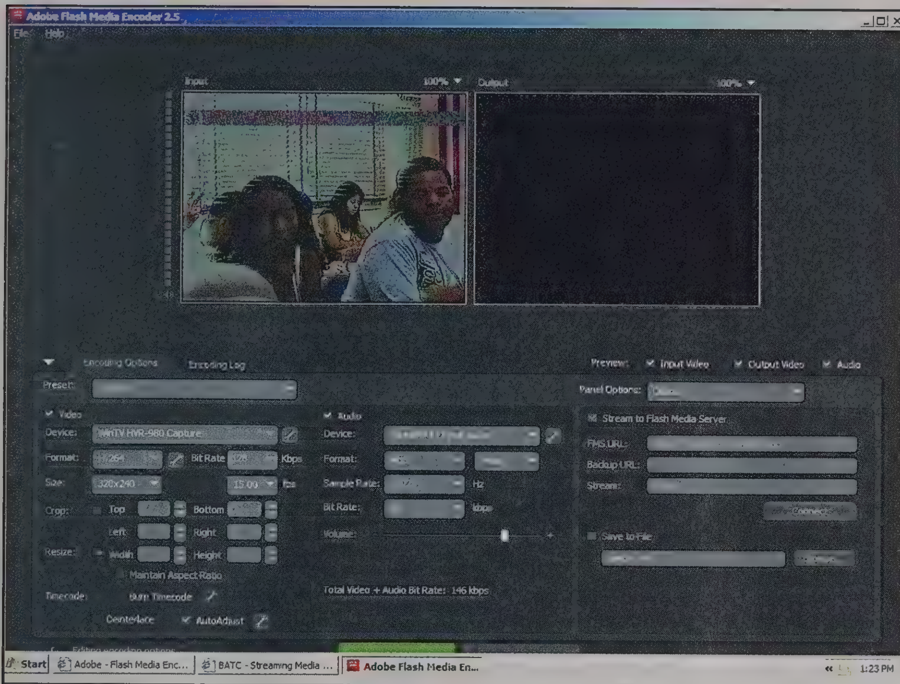


Carolina Martinez demonstrating how to add fractions in three easy steps.



Shani Coca explaining how to add fractions with different denominators.

**c/o Pueblo Magnet High School Amateur Radio Club, 3500 S. 12th Ave., Tucson, AZ 85713*
e-mail: <enriquezma@cox.net>



Marcus Nesbitt and Olivia Payne posing for the camera as the ATV signal is calibrated for live streaming via BATC.TV.

view and benefit from these presentations. Interested classroom instructors must have a computer connected to the internet in the classroom. What this means is that in the next few weeks, you too can tune to our ATV signal via your computer. These same presentations will also be videotaped and "rebroadcast" at later times.

The premise of the program, which is called "Kidz-Teaching-Kidz," is that children learn faster and more easily from other children. Call it more appropriate levels; call it better comprehension; call it what you must. However, research has demonstrated repeatedly that kids learn better from other kids.

The Pueblo ARC students will not be presenting math instruction in its entirety. Rather, the Pueblo ARC students will be teaching those areas in which many students traditionally have problems. Subjects such as fractions, decimals, number sense, and recognizing patterns are first on the teaching schedule. Admittedly, the math instruction via ATV concept is still in its infancy and we have yet to articulate an entire curriculum. However, as one of my students said, "So what if we're not good at this? At least we are getting more confidence standing in front of a camera and having our friends and parents see us trying to do the math. We can't go wrong."

While our efforts at introducing ATV to other Tucson hams have not been as successful as we would like, our efforts continue. The school has three stations, one fixed and two portable. The students use the two portable stations at other schools, hamfests, and other venues to demonstrate ATV QSOs. It is via these students' efforts that we hope to grow ATV activity in Tucson and the outlying areas. In my next column I will highlight some of our successes in increasing ATV activity. In the meantime, we remain true to our cause: to develop our ATV knowledge and skills as we find ways to use ATV to make a significant contribution to our community.

The efforts to get and improve the ATV signal from our classroom to the repeater atop Mt. Lemmon and back are on the "completed" list. Our efforts to get that same signal from our downconverter into our classroom computer and onto the internet required a more circuitous route. Thanks to the steadfast leadership of Ron Phillips, AE6QU; the technical brilliance of Mike Collis, WA6SVT; the know-how, advice, and direction of Don Hill, KE6BXT; and late-night and early-morning testing QSOs with Ian Abel, G3ZHI, in England, that activity is now also on the "completed" list.

To feed the signal into the internet, we are using the Hauppauge WinTV-HVR-950 Hybrid Stick. The "F" connector to USB connector function makes it ideal for PC and laptop use. The Adobe Flash Media Encoder 2.5 is a free download and is easy to setup and use. Finally, what makes this entire process possible is the British Amateur Television Club site in England, where our signal is streamed to and presented over the World Wide Web.

Already our students' parents are anticipating watching their children on their computers at home. Already our ARC is preparing for the delivery of those lessons and working hard to create the supportive television environment and required facility. Already the Pueblo ARC students are scheduling themselves to visit other amateur radio clubs in our community and to tell them about their activities.

Plans to connect our students with a school in England have been preliminarily discussed. The biggest challenge we face in doing this is the seven-hour difference between the two locations. Yet I suspect that because ham radio is involved, the dedication, commitment, and resilience that have made ham radio magic for over a hundred years will rise once again to find an equitable solution even for that issue.

If you are interested in watching our students hard at work, please send an e-mail to <miguel.enriquez@tusd1.org> for specific instructions on how to access our site, or simply go to <http://www.batc.tv> and look for KD7RPP or W7ATN in the Members Streams menu.

73, Miguel, KD7RPP

About KD7RPP and AE6QU

CQ VHF magazine ATV column editor Miguel Enriquez, KD7RPP, is a mathematics teacher at Pueblo Magnet High School in Tucson, Arizona. He also sponsors the Pueblo Magnet High School Amateur Radio Club. W7ATN is the repeater that sits atop Mt. Lemmon at an altitude of 9,238 feet.

Ron Phillips, AE6QU, is a benefactor of the Pueblo Magnet Amateur Radio Club who provides untiring technical advice, equipment, and other contributions to the ARC. Ron also attends ham-radio-related meetings and conferences in the Phoenix, Arizona area to the benefit of the Pueblo ARC.

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

AMSAT and Teacher Professional Development

Our last column (Summer 2008 *CQ VHF*) discussed the National Science Education Standards. In it I attempted to show why AMSAT must demonstrate compliance with those standards in developing a meaningful Teacher's Institute. It was my intention to show how AMSAT can provide a credible professional development opportunity for educators, while advancing our own educational goals. Since that column was submitted, there have been significant changes in AMSAT's educational direction. It is my hope to explain those changes in this, the final installment of "The Orbital Classroom."

Most school districts tie advancement (and in some cases continued employment) to specific continuing education requirements. Generally, a teacher is required to receive a specified number of Continuing Education Units (CEUs) during a stated period of time to meet a given school district's professional development requirements. Unfortunately, the scope of acceptable activities and level of rigor necessary to grant CEUs vary from state to state. However, AMSAT intends to provide continuing education opportunities for teachers from all 50 states. In order to grant CEUs, we would need to have our curriculum scrutinized and approved by 50 Departments of Education in separate states (each of which may have different, possibly conflicting, standards). Thus, it is my recommendation that we *not* pursue granting of CEUs.

There is, however, an alternative to CEUs. Most school districts will allow professional development credit for relevant postgraduate-level courses from any accredited university. Also, AMSAT, by virtue of its Memo of Understanding with the University of Maryland, Eastern Shore (UMES), is party to an educational partnership that just might make such postgraduate-level courses feasible.

UMES is home to the Hawk Institute for Space Sciences (HISS), host for the AMSAT Satellite Integration Facility ("AMSAT Lab"). We have already partnered with HISS on a number of educational initiatives, including student involvement in satellite construction activities in our lab, and student participation in balloon launches carrying amateur radio payloads. Thus, using their facility to educate educators is a logical next step.

Although UMES is an undergraduate institution, it is part of the University of Maryland system, which does indeed grant graduate credits. If our Teacher's Institutes can be approved by that university for graduate credit, participating educators from all states can apply it toward the continuing education and professional-development requirements of their particular school districts.

OK, so we began to develop a game plan for offering accredited, post-graduate training for educators through our existing university partner. Of what should such training consist? Clearly, we would love to see schools across the country equipped with OSCAR ground stations, tracking and communicating through ham satellites. Remember, though, that any effort in that direction must be consistent with the National Science Education Standards outlined in the previous "Orbital Classroom" column. Simply preparing teachers to have their students play ham radio through satellites isn't going to cut it.

Here's where a serious curriculum development effort appeared needed, and I am proud to say that several AMSAT educational volunteers stepped up to the plate. However, before reinventing the wheel, I thought it prudent to survey other professional-development opportunities for educators which also focused on satellite communication and related technologies. To my surprise, I found quite a few competing programs already well in place.

Closest to home for most AMSAT members is the excellent ARRL educational program headed by our friend Mark Spencer, WA8SME. Mark was most helpful and encouraging to me when I first was appointed AMSAT Director of Education in early 2006, and he generously offered to share his curriculum with us. He presents four to six Teacher's Institutes a year in various parts of the country, and through a partnership with an accredited university is able to offer participating teachers postgraduate credit suitable for their professional-development needs. These week-long intensive courses cover many aspects of amateur radio, including an excellent introduction to amateur satellites. In fact, in their professional capacity as classroom teachers, a number of AMSAT members have already taken Mark's courses. As the national association for amateur radio in the U.S., the ARRL has been quite successful in securing financial contributions toward its educational efforts. Consequently, many participating educators are able to attend these ARRL courses free of charge, and some have even been awarded grants to equip their laboratory facilities and campus amateur radio stations. AMSAT salutes the ARRL for making this worthy educational contribution.

The ARRL is not alone in its continuing education offerings, although the extent of its emphasis on amateur radio is unique. Professional organizations such as the American Astronomical Association, American Association for the Advancement of Science, American Institute of Aeronautics and Astronautics, and others also offer professional development to educators in areas that overlap AMSAT's expertise. Because of the extensive financial resources of these large

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organizations and their commercial sponsors, the cost to individual teachers is minimal, with stipends offered to encourage the most cash-strapped school districts to participate. Often, these workshops are offered at exotic vacation venues, making it easier for participating educators to gain the support of their respective families. I once attended such a summer course under the sponsorship of the school district where I was then employed. Although, regrettably, it lacked amateur radio content, that course emphasized the use of computers in the classroom at a time when that idea was still novel and provided an enjoyable and professionally rewarding experience.

NASA has long promoted aerospace education through its SpaceMobile program, run for it for decades by the University of Oklahoma. The program features laboratory and demonstration equipment built into vans, fanning out across the country to visit primary and secondary schools in every state. Astronauts are frequent speakers at SpaceMobile events, and although their emphasis has been motivation of students, many a classroom teacher has received professional development credit through SpaceMobile workshops.

Recently, a new contract for the NASA Aerospace Education Services Project (AESP) was issued to the Pennsylvania State University's Center for Science and the Schools. With PSU becoming NASA's new ASEP higher education partner, some changes in emphasis ensued which promised to prove valuable to AMSAT. Instead of just sending SpaceMobiles around to the K–12 schools to put on road shows for the students, they announced a new thrust in teacher continuing education. Because this meshes well with AMSAT's proposed professional development plans for educators, I met in December 2007 with Dr. Bill Carlsen, Penn State's Principal Investigator for this new NASA contract. From that meeting an AMSAT action plan began to emerge.

As worthy as it might be for AMSAT to provide teachers with continuing education in satellite communications, I reasoned, the cost (both monetary and in terms of effort required) threatened to siphon off AMSAT resources already stretched thin by our various satellite development programs. Why not instead, I suggested, partner with the ARRL, NASA, Penn State, and AIAA and everybody else already filling the educators' technology professional development niche? In January 2008 I proposed to the AMSAT leadership team that our talents could best be spent by developing, and volunteering to teach, satellite design, satellite construction, and satellite operations *modules* for all of those organizations currently offering teacher continuing education in related fields. It's not as glamorous as having our own Teacher's Institute, I realize, but it just might be more compatible with AMSAT's primary mission.

I had thought I had made a reasonable case, but I am an educator, not a policy maker. Ultimately, the AMSAT board decided to go in a different direction, and in February 2008 I was asked to step down as AMSAT Director of Education. I will not second-guess our leadership in that decision, but did want the AMSAT membership to know the path that brought us to this juncture. Also, I will continue to support, to whatever extent I am able, the educational efforts the AMSAT Board ultimately decides to pursue, consistent with our organization's vision and mission statements.

I urge all of you to support such future AMSAT educational efforts as well.

73, Paul, N6TX

CQ's Satellite WAZ Awards

(As of October 1, 2008)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>*

RSGB Books

View more RSGB books on our web site!

Guide to VHF/UHF Amateur Radio

By Ian Poole, G3YWX

2000 Ed.,112 pgs.
Everything you will need to help you enjoy VHF/UHF to the fullest. Choosing the right transmitter, receiver, antenna, utilizing the correct part if each band and more!

Order No. RSGVUAR ***$16.00***

Antenna Toolkit 2

By Joe Carr, K4IPV

RSGB & Newnes, 2002 Ed., 256 pgs.
A definitive design guide for sending and receiving radio signals. Together with the powerful suite of CD software included with this book, the reader will have a complete solution for constructing or using an antenna; everything but the actual hardware!

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Practical Wire Antennas 2

By Ian Poole, G3YWX

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QRP Basics

By Rev. George Dobbs, G3RJV

2003 Edition, 208 pages
How to get the best results from a QRP station whether from home or outdoors. How to construct your own station, complete transmitters, receivers and some accessories. Sections include toroidal coils, constuction techniques and equipping a work station.

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VHF/UHF Amateur Radio

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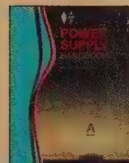
Order: RXVUH ***$29.50***

HF Antenna Collection

2nd Ed., 2002. 252 pages.
A collection of outstanding articles and short pieces which were published in *Radio Communication* magazine. Includes single- and multi-element, horizontal and vertical antennas, extremely small transceiving and receiving antennas, feeders, tuners and much much more!

Order: RSHFAC ***$33.00***

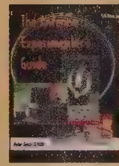


Power Supply Handbook

By John Fielding, ZS5JF

2006 Ed., 288 pages.
How power supplies work, selecting components. building and modifying supplies, measuring he finished supply, batteries, chargers, test equipment - it's all here!

Order: RSPSH ***$28.50***



The Antenna Experimenter's Guide

2nd Ed., 1996. 160 pages.
Takes the guesswork out of adjusting any home-made or commercial antenna, and makes sure that it is working with maximum efficiency. Describes RF measuring equipment and its use, constructing your own antenna test range, computer modeling antennas. An invaluable companion for all those who wish to get the best results from antennas!

Order: RSTAEG ***$32.00***

The Low Frequency Experimenter's Hdbk

By Peter Dodd, G3LDO

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Technical Topics Scrapbook 1995-1999

By Pat Hawker, G3VA

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This third compilation of 'Tech Topic' articles is a fascinating collection of circuit ideas, antenna lore, component news and scientific discussion, all at the most practical level

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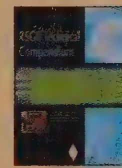

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Design and construction of hundreds of antennas. No matter what your location, there's one for you!

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QUARTERLY CALENDAR OF EVENTS

Current Contests

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 15–16, 2008.

January: The ARRL VHF Sweepstakes is scheduled for the weekend of January 17–19, 2009.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or the League's URL: <http://www.arrl.org>.

Current Meteor Showers

November: The *Leonids* shower is predicted to peak around 0900 UTC on November 17.

December: Two showers occur this month. The first, the *Geminids*, is predicted to peak on December 13. The actual peak can occur 2.5 hours before or after the predicted peak. It has a broad peak and is a good north-south shower producing an average of 100–120 meteors per hour at its peak.

The second, the *Ursids*, is predicted to peak around 0730 UTC on December 23. It is an east-west shower, producing an average of no more than 10 meteors per hour, with the rare possibility of upwards of 90 meteors at its peak.

January: The *Quandrantids,* or *Quads*, is a brief, but very active meteor shower. The expected peak is on January 3–4, with the best time being the morning of January 4 just after midnight and working through dawn, with up to 40 meteors per hour at its peak. The actual peak can occur three hours before or after the predicted peak. The best paths are north-south. Long-duration meteors can be expected about one hour after the predicted peak.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's "VHF Propagation" column starting on page 77. Also visit the International Meteor Organization's website: <http://www.imo.net>.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

Nov. 2	Moon Apogee. Very poor EME conditions.
Nov. 6	First Quarter Moon.
Nov. 9	Good EME conditions.
Nov. 13	Full Moon.
Nov. 14	Moon Perigee.
Nov. 16	Moderate EME conditions.
Nov. 17	*Leonids* Meteor Shower Peak.
Nov. 19	Last Quarter Moon.
Nov. 23	Moderate EME conditions.
Nov. 27	New Moon.
Nov. 29	Moon Apogee.
Nov. 30	Very poor EME conditions.
Dec. 5	First Quarter Moon.
Dec. 7	Good EME conditions.
Dec. 12	Full Moon, Moon Perigee and Full Moon.
Dec. 13	*Geminids* Meteor Shower Peak.
Dec. 14	Moderate EME conditions.
Dec. 19	Last Quarter Moon.
Dec. 21	Winter Solstice. Moderate EME conditions.
Dec. 27	New Moon.
Dec. 28	Very poor EME conditions.
Jan. 3	Moon Apogee.
Jan. 4	*Quadrantids* Meteor Shower Peak and First Quarter Moon. Moderate EME conditions.
Jan. 10	Moon Perigee.
Jan. 11	Full Moon. Good EME conditions.
Jan. 18	Last Quarter Moon. Moderate EME conditions.
Jan. 23	Moon Apogee.
Jan. 25	Very poor EME conditions.
Jan. 26	New Moon.
Feb. 1	Moderate EME conditions.
Feb. 2	First Quarter Moon.
Feb. 7	Moon Perigee.
Feb. 8	Very good EME conditions.
Feb. 9	Full Moon.
Feb. 15	Poor EME conditions.
Feb. 16	Last Quarter Moon.
Feb. 19	Moon Apogee.
Feb. 22	Poor EME conditions.
Feb. 25	New Moon.

—EME conditions courtesy W5LUU.

Correction

In the Summer 2008 issue of *CQ VHF* in the article "Loe-Noise Pre-amplifiers for the 1.3, 2.3, and 3.4 GHz Amateur Bands," by Sam Jewell, G4DDK, photo D was a duplicate of photo B. The correct photo of the 3.4 GHz LNA, L1 and L2 input hairpin loop details appears here. We apologize for any confusion caused by the error.

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

A Decade of ARDF in the USA

In 1998, amateur radio hidden-transmitter hunting in the USA was almost exclusively a vehicular activity. A weekend hunt in most places meant hours of driving in a well-equipped vehicle. There might be an on-foot "sniff" at the end to get to a transmitter a few yards off the road, but that was the extent of fox-hunting on foot.

Back then, only a handful of North American hams had experienced the kind of transmitter hunting that was predominant in Europe and the Asian mainland. In those countries, hams had combined radio direction finding (RDF) with map-and-compass orienteering to create a sport that challenged both the mind and body. In some places, particularly Russia and former Soviet bloc nations, it was being used in physical-education classes for youth in schools and by the military for field training.

The first ARDF Team USA in Hungary at the 1998 World Championships. Left to right are Gyuri Nagy, HA3PA; Marvin Johnston, KE6HTS; Dennis Schwendtner, WB6OBB; Dale Hunt, WB6BYU; and Jack Loflin, KC7CGK. Nobody brought a mast for the American flag, so WB6OBB, who is blind, offered his white cane. (Photo by Barbara Johnston, KE6OTF)

This international on-foot-only sport had acquired several names, including foxtailing, foxteering, radio-orienteering, and ARDF, for Amateur Radio Direction Finding. Official rules were put in place by a committee of the International Amateur Radio Union (IARU). A course has five "fox" transmitters in a large wooded area of at least 500 acres, and usually much larger. Participants start near one end and proceed to the other end, punching in at each fox along the way.

Radio-orienteers must pay constant attention to all bearings, because each fox is on for 60 seconds, one at a time, in sequence. For instance, when #1 goes off, then #2 comes on and #1 won't be back for four minutes. A continuous transmitter on a separate frequency is near the finish to aid hunters who have lost their place on the map.

The first foxtailing events were on 80 meters with CW transmitters sending "MO" followed by dits indicating the transmitter number (MOE, MOI, MOS, MOH, and MO5). Later, a separate contest on 2 meters was added to each meet, with CW tones on AM carriers. This was before the popularity of narrowband FM on 2 meters, but AM predominates on VHF at international ARDF events to this day.

Starting with separate divisions for all men and all women, the organizers began to add categories for youth and "old timers," as regular participants reached the ripe old age of 40. All women, regardless of their age, were placed into a fourth category.

National team members must work independently. No assistance or cooperation of any kind is allowed on the courses, except for injuries and other emergencies, of course. Team scores are aggregates of individual member scores. Use of GPS and other navigation devices on the course is forbidden.

A Good Start in Hungary

The first ARDF "world" championships in 1980 attracted participants from only 11 European countries. Asia was not represented until four years later, but activity grew quickly there, especially in China and Japan. In the mid-1990s, over 20 countries were participating, but IARU officials bemoaned the "black hole" in Region 2 (North and South America), where no foxtailing was taking place. That was about to change, because some hams on our West Coast had tried ARDF, liked it, and wanted to move it into the mainstream of American ham radio.

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e-mail: <k0ov@homingin.com>

An informal ARDF Task formed in 1997 with the goal of hosting the first IARU Region 2 ARDF Championships in Portland, Oregon during the summer of 1999.[1] This would be combined with the sixth Friendship Radiosport Games, a sister-cities event with participation by hams from Khabarovsk in Russia, Niigata in Japan, and Victoria in British Columbia, Canada.

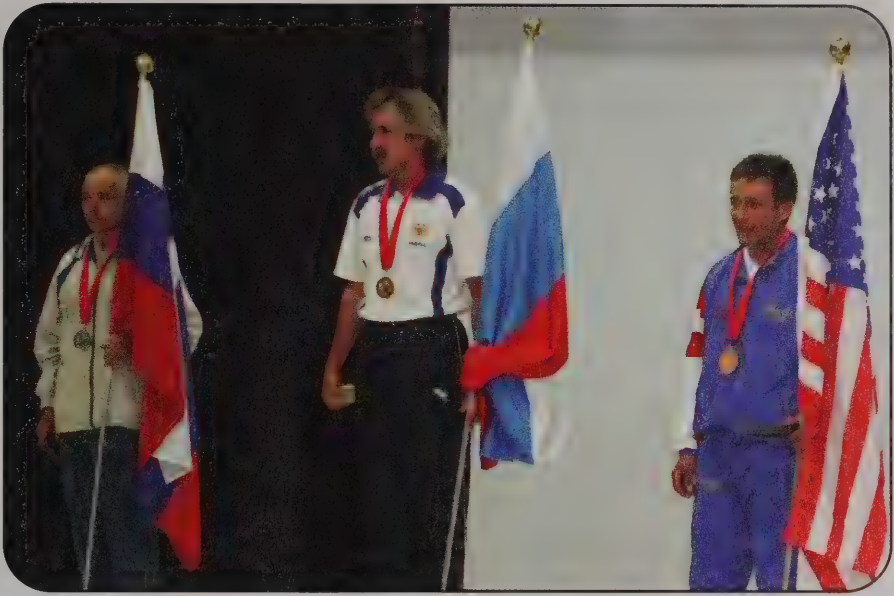
In early 1998, the ARRL Board of Directors formally recognized the desirability of developing ARDF in the U.S. I was appointed to be the ARRL's ARDF Coordinator. There was no formal job description (and still isn't one), but it was agreed that I would lead the promotion and development of ARDF in the U.S., working closely with radio clubs and organizations here, as well as with IARU and other member societies in the scheduling and promotion of foxtailing events.

Shortly thereafter, I received an invitation from Rik Strobbe, ON7YD, the Interim Chair of Region 1's ARDF Working Group. He wanted the U.S. to send a team to the 1998 ARDF World Championships (WCs) in Hungary. This would be an excellent opportunity for stateside hams to observe the mechanics of international-style competitions, which would be important for our upcoming event. We would also learn course strategies by watching and meeting with the medal-winning experts.

I put out the word, and by the middle of summer the U.S.'s first team had formed. Dale Hunt, WB6BYU, Marvin Johnston, KE6HTS, and Jack Loflin, KC7CGK, would try the courses. Dennis Schwendtner, WB6OBB, and Barbara Johnston, KE6OTF, would accompany them. Then an e-mail arrived from Gyuri Nagy, HA3PA. As an engineer for an international company, he often traveled to the U.S. and had been given resident alien status.

Gyuri offered to meet the delegation in his native country and help prepare everyone for the competition. He also offered the use of his 80-meter ARDF equipment. In return, he wanted to know if he could join our team and compete for the U.S. A check with IARU officials revealed that Gyuri's green-card status made it okay for him to represent our country.

Gyuri picked up the stateside delegates at the Budapest airport and drove everyone to Nyiregyhaza, the site of the competitions. The amount of pomp and ceremony there was surprising. Like the Olympics, there was a parade of the ath-



On the 2008 ARDF World Championships awards podium for category M50, left to right are silver medalist Stanko Cufer, S57CD, of Slovenia; gold medalist Igor Kekin of Russia; and bronze medalist George Neal, KF6YKN of the USA. (Photo by Jay Hennigan, WB6RDV)

The U.S. delegation to the 2008 ARDF World Championships in Korea. Left to right are Bob Cooley, KF6VSE; Ken Harker, WM5R; Jen Harker, W5JEN; Dale Hunt, WB6BYU; Harley Leach, KI7XF; Nadia Scharlau; George Neal, KF6YKN; Scott Moore, KF6IKO; Vadim Afonkin; Jay Thompson, W6JAY; Charles Scharlau, NZØI; and Jay Hennigan, WB6RDV. Not pictured is Richard Thompson, WA6NOL, who took the photo. (Photo courtesy Vadim Afonkin)

letes by nation, each team following a placard-carrying local escort. The opening festivities also included native dancing and other entertainment.

The next day was the 2-meter event, then a day of rest and organized tours, followed by the 80-meter hunt day. All Team USA members successfully completed the courses, but our inexperience and Gyuri's lack of recent training kept us off the winners' podium. Most medals went to eastern European and former Soviet Union countries because of their high level of experience and participation in local events.

Bringing It Home

This trip to Hungary, as the old song goes, was the start of something big. WB6BYU used the knowledge he had gained to set challenging 2-meter and 80-meter courses at well-mapped sites for the 1999 Friendship Games and IARU Region 2 Championships. Besides the Friendship Society participants from Russia, Japan, and Canada, the event attracted foxtailers from Australia, Bulgaria, Kazakhstan, and Sweden to the City of Roses.

Before traveling to Portland, Gyuri visited KE6HTS in Santa Barbara. They went to a VE session where Gyuri easily passed the tests to become KF6YKN. On the courses in Oregon, it became clear that he had resumed his ARDF training. He posted the best five-fox time of the day in the 80-meter event, even though he was the oldest in his age category.

The 2000 WCs were on the Asian continent for the first time. The Chinese Radiosports Association hosted and WB6BYU was invited to serve on the international jury. Nine hams represented the U.S. on the courses, including 15-year-old Jay Thompson, W6JAY, whose mother is of Chinese descent. KF6YKN ran in the prime-age Senior category with five foxes to find, even though he was qualified by age for the four-fox Old Timers category. There was also a new four-fox category for Veterans, meaning men ages 55 and up. One of the USA's two Veterans was Bob Cooley, KF6VSE, who became the first Team USA member to finish in the top ten in his category.

IARU rules allow a maximum of three persons in any age/gender category on any national team at the WCs. Even with the addition of the Veteran category, the growing interest in the sport would soon make it impossible to allow everyone with the desire to join Team USA. I set two qualifying courses in southern California to help select and train Team USA 2000, but something better was needed for the future.

Amateur radio societies all over the globe stage national ARDF championships to build interest and to find out who is most deserving of a spot on their teams. Members of the Albuquerque Amateur Radio Club stepped forward to host the First USA ARDF Championships in the summer of 2001. National championships have become an annual tradition ever since, open to anyone of any age, with or without a ham radio license. Besides the best radio-orienteers of the states, there have been visiting competitors from seven foreign countries over the years.

In 2002, IARU rules changed to specify nine age categories, five for males and four for females. Men over 60 and women over 55 need to find only three of the five foxes. Competitors don't get to choose which foxes not to find. The skipped foxes in each category are specified in the IARU rules.

U.S. teams continue to improve in this decade, with Gyuri in the lead. For the 2002 WCs in Slovakia and the 2004 WCs in the Czech Republic, he put on training camps beforehand near his home town of Pecs, Hungary. Most Team USA members participated, as well as two Team Australia members who had visited at our 2001 national championships. KF6YKN rented a house for the group and put out several full-length ARDF courses, plus sprints and orienteering practice. After that, everyone went to the Hungarian national championships for even more practice on very long courses.

Harley Leach, KI7XF, in the 2-meter finish corridor at the 2008 World Championships. He fabricated his Yagi antenna from aluminum stock. Notice the holes in the boom to make it lighter. (Photo by Dale Hunt, WB6BYU)

Bob Frey, WA6EZV, our team's co-captain in 2002, wrote, "I was tickled to death with Gyuri's training camp! It was fantastic!" KF6YKN took fifth in his category in the 2-meter hunt at the WCs in Slovakia, less than six minutes short of a medal. He accomplished that even though he was in need of knee surgery, which took place shortly thereafter.

In 2006, KF6YKN was granted U.S. citizenship and he changed his name to George Neal. On the Black Sea coast of Bulgaria that year, Team USA captured its first WC medal. Nadia Scharlau of North Carolina was awarded a tie for third place on 80 meters in the four-fox category for women over 35. She would have won it outright, but the homing beacon transmitter failed just as she punched in at her last fox and needed the beacon to navigate quickly to the finish line. After a thor-

As a member of the international jury at the 2008 World Championships, Ken Harker, WM5R, was stationed at fox #4 during the 2-meter and 80-meter competitions. Ken was co-chair of the organizers of the 2008 USA ARDF Championships in Bastrop, Texas. (Photo courtesy WM5R)

ough review, the international jury gave her the medal.

Another Medal This Year

Radio-orienteers of the world returned to Asia this year, as the Korean Amateur Radio League hosted the 14th ARDF WCs from September 2 through 7 at a resort in Hwaseong, just outside of Seoul. As the USA's ARDF Coordinator, I issued invitations to 22 persons to compete for our country, based on their finishes in the 2007 and 2008 national championships. Because of economic considerations and activity conflicts, only 11 were able to accept.

Among those accepting was WB6BYU, but a few weeks before the trip Dale was diagnosed with gout. Although he was hopeful that his foot pain would diminish enough for him to run in Korea, it was not to be. He traveled there anyway to attend meetings with officials from IARU Regions 1 and 3. He also served as Team USA's Captain, which meant going to even more meetings.

As one who had organized ARDF championships in the past, WB6BYU was impressed by the Koreans' high level of organization and attention to detail. "There were a lot of things that can go wrong that the officials had anticipated," he told me. "I was amazed by the number of volunteer hams that they had to help them. Everywhere you went, there were about 20 people in black vests with 'KARL volunteer' on them. At the opening ceremony, there had to be a hundred folks handling things."

These championships drew far more people than the 300 originally planned for. The final attendance was about 330 competitors and more than a hundred official visitors. The hotel had a limited number of rooms with beds, so those arriving later ended up with Korean-style sleeping arrangements—thin mats on the floor. "The pillows were little tiny things that felt like they were full of Rice Crispies," one reported.

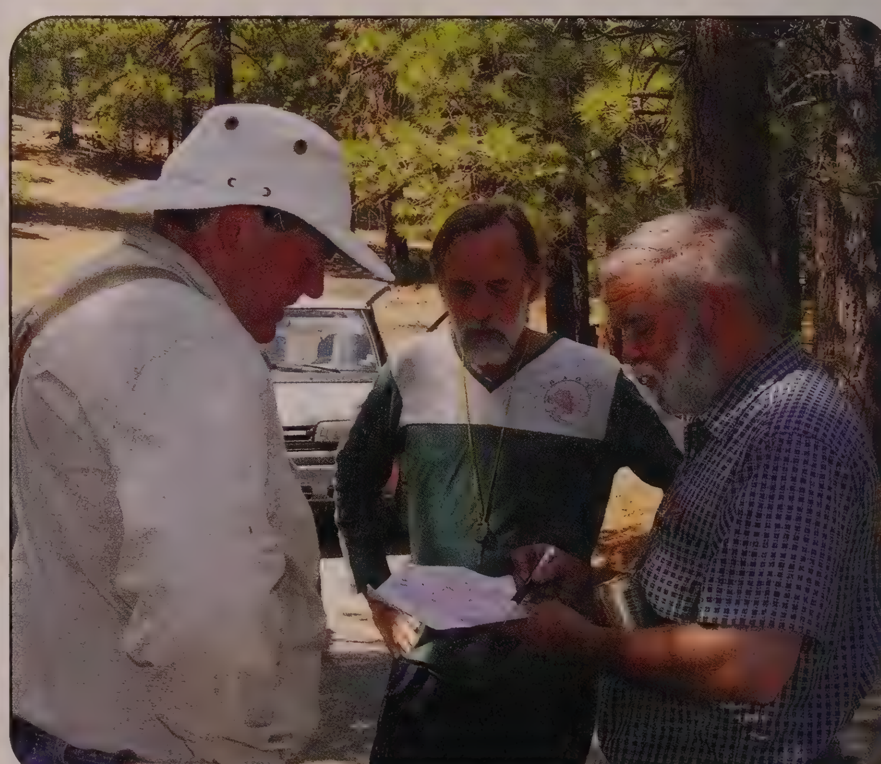
Team USA gave good marks to the food, which was served from large buffet tables in the gardens outside the hotel when weather permitted. "They had something for everyone," WB6BYU explained. "There was bread for the Russians, processed meat for the Germans, and so forth. One of our team members expressed surprise that they were serving lasagna for breakfast. He was even more surprised when he took a bite of it and it turned out to be kimchi."

Jennifer Harker, W5JEN, unfolds her 2-meter measuring-tape Yagi in preparation for the 2-meter hunt at the 2008 World Championships. She designed the courses for this year's USA Championships in Bastrop State Park after earning her team position at South Lake Tahoe in 2007. (Photo by Dale Hunt, WB6BYU, courtesy W5JEN)

Lined up at the start of the Bastrop Park 2-meter competition on May 9 are, left to right, Vadim Afonkin, Michael Bayern, W2CVZ, and Mike Urich, KA5CVH. Several runners, all in separate age/gender categories, started together as fox #1 came on the air each cycle. At age 12, W2CVZ was the youngest competitor at this year's national championships. (Photo by Joe Moell, KØOV)

The 2400-acre 2-meter contest site was a far cry from the usual European forests. About 40 percent of the map was marked yellow, meaning easy to navigate. However, these parts turned out to be drained rice paddies and fields of other crops, such as soybeans and bok choy. This was a first for most competitors. They wore new trails through these muddy areas and couldn't help trampling some of the plants. The farmers' dogs could be heard barking in the distance, but fortunately the dogs were confined and the farmers didn't seem to mind.

As always, the Russians, Ukrainians, and Czechs dominated the medal count,[2] taking home 92 percent of the gold medals. However, the U.S. did better than ever, with four finishes in the top ten. For the second time at the WCs, the Stars and



Marvin Johnston, KE6HTS (right), organized two training camps in the mountain forests for ARDF Team USA 2008. Participants included first-time team member Scott Moore, KF6IKO (left), and Bob Cooley, KF6VSE (center), who finished in seventh place in his category during the 80-meter event in Korea. (Photo by KØOV)

Stripes were displayed in the awards ceremony. This time it was by George Neal.

KF6YKN led our team by capturing a bronze medal in the category for men between ages 50 and 59 in the 2-meter foxhunt. He found all four required transmitters and got to the finish line in 1:23:42, less than six minutes behind gold medalist Igor Kekin of Russia. Our other top-ten finishers, all in the 80-meter event, were Vadim Afonkin of Boston, who was fifth in M40 category, Bob Cooley, KF6VSE, of Pleasanton, CA, who was seventh in M60, and Nadia Scharlau of Cary, NC, who was ninth in W35.

Selecting and Training the Team

For most Team USA members, the road to Seoul went through central Texas. This year's USA ARDF Championships took place from May 8 through 10 in Bastrop State Park, about an hour's drive east of Austin. Unlike most of the Lone Star State, Bastrop Park is hilly and heavily wooded, with loblolly and other pines, making it ideal for radio-orienteering. Houston Orienteering Club has done an excellent job of mapping it.

Organizing the USA Championships this year were Kenneth and Jennifer Harker, WM5R and W5JEN, of Austin. They had competed at the USA Championships in 2003, 2005, 2006, and 2007. Each won medals on both bands at South Lake Tahoe last year. W5JEN qualified for ARDF Team USA in the W21 category. WM5R was invited to serve on the international jury in Korea.

This year's participants ranged in age from 12 to 66 and came from nine states, plus Canada. They braved snakes, spiders, and poison ivy to track down the transmitters without injury. Packing gold medals in their suitcases for the trip home were Vadim Afonkin (M21, 2m and 80m); Michael Bayern, W2CVZ (M19, 2m and 80m); Jerry Boyd, WB8WFK (M50, 2m); Bob Cooley, KF6VSE (M60, 2m); Jay Hennigan, WB6RDV (M50, 80m); Harley Leach, KI7XF (M60, 80m); Nadia Scharlau (W35, 2m and 80m) and Charles Scharlau, NZØI (M40, 2m and 80m).

Ken and Jen got high marks for organizing a successful championships, which included a catered lasagna feast on Friday night when the 2o-meter medals were presented. The 80-meter hunt on Saturday started early and the electronic scoring (provided by KE6HTS and the Los Angeles Orienteering Club) made it possible to award the medals and get the out-of-towners to the airport in time to be home for Mother's Day.

Following the qualifying events in Texas, there were two excellent preparation opportunities for Team USA members this summer. KE6HTS organized a pair of weekend training camps in the Sierra Madre mountains of southern California, near Mount Pinos. All of the Californian members of the team took part as Marvin used the training techniques he had learned from KF6YKN. He started by putting them through a world-class 2-meter ARDF course on Saturday morning, starting at 8425 feet elevation.

After snacks and recovery of the transmitters, Marvin set out a low-power sprint course in the campground. The hunters' goal was to find each fox during its first one-minute transmission of the sequence. A perfect run would take just five minutes, plus a couple of minutes to return to the finish line. On Saturday evening everyone gathered in a nearby park, and Marvin heated up the charcoal and roasted Santa Barbara style tri-tip beef for everyone. Then on Sunday morning, KE6HTS set a full five-fox course on 80 meters.

A Big Year Ahead

ARDF activity is winding down for 2008. There will be a couple more local hunts in southern California before the holidays, but it is getting too chilly for radio-orienteering in most of the rest of the country. Now the plans for 2009 are coming together. The three IARU regions will hold championships for member countries and visitors. The Region 1 championships will be in Bulgaria during September and Region 3 in Thailand during November.

In addition to Region 2, the ARRL is a dues-paying member of IARU Region 3 because of the American territories in the western Pacific. As a result, the U.S. has officially been invited to send a team to compete in Thailand next year. If you are interested in going, please contact me.

I expect to announce the USA and IARU Region 2 championships location and dates soon. Check my "Homing In" web site,[3] as the dates and location may be available by the time you read this. My site also has many photos of the 2008 USA and World ARDF Championships as well as links to even more photos from the participants.

Our 2009 national championships will start the selection process for the 2010 team, which will go to the Adriatic coast of Croatia for the next WCs. Some new rules will be in effect, realigning the women's age categories to be the same as they are presently for men: W19, W21, W40, W50, and W60. A new category for men age 70 and up will be added.

Many thanks to all of you who have sent information on transmitter hunting activities in your area, both mobile and on foot. I welcome your stories and photos via e-mail or postal mail to the addresses at the beginning of this article.

73, Joe, KØOV

Notes

1. ARDF WCs take place in even-numbered years. In odd-numbered years, each of the three IARU regions is encouraged to hold its own international ARDF championship event.
2. Read about a visit to the USA from the Ukrainian ARDF Team Physician in "Homing In" in the Winter 2008 issue of *CQ VHF*.
3. <http://www.homingin.com>

By Bob Witte,* KØNR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

How to Crossband on VHF/UHF

One handy feature that has made its way onto the list of standard features for many dualband FM transceivers is *crossband repeat* mode. This mode can be really useful for extending our radio range, and but it does come with a few challenges to consider.

Photo A. A typical dualband radio that includes crossband repeat mode. (Photo via KØNR)

Two Radios in One

In a dualband FM transceiver (photo A) crossband repeat capability takes the signal from one band and retransmits it on the other band. Typically, the two bands are 2 meters (146 MHz) and 70 cm (440 MHz), although other bands may come into play. Not all dualband transceivers are able to do crossband repeat. A key enabler is that the dualband rig must have two independent receivers that can operate simultaneously. Examples of two-receiver dualband rigs are the Alinco DR-635T, ICOM IC-2820H, Kenwood TM-V71A, and Yaesu FT-8800 and FT-8900. (The crossband repeat feature is not shown in the IC-2820H manual, so visit the ICOM website for details on how to enable it.) Examples of dualband radios that are "one frequency at a time" and don't offer crossband repeat are the Yaesu FT-7800R and the ICOM IC-208H.

As you may have experienced, a transmitter operating in close proximity to a receiver can overload the receiver, causing radio interference. In the case of 2 meters and 70 cm, the frequency spread is wide enough such that the front end of a well-built transceiver can keep the two bands from interfering. Note that these radios only repeat between different bands. They don't have the ability to repeat one 2-meter frequency to another 2-meter frequency, as there is insufficient isolation inside the radio. (Real repeaters use very large cavity filters to accomplish this.)

Inside the radio, crossband repeat is implemented via a logical connection between the squelch line of the receiver and the transmit control of the transmitter. In other words, when the squelch opens on one of the receivers, it causes other band's transmitter to turn on. The audio is routed from the receiver to the transmitter so that the signal is repeated. This feature generally works in both directions; signals on 2 meters are repeated on 70 cm and signals on 70 cm are repeated on 2 meters. Some transceivers offer a "one way" crossband repeat that allows the retransmissions to occur in only one direction. Early implementations of crossband repeat mode had limitations such as simplex only (no repeater transmit offset) and limited use of CTCSS. These days, crossband repeat can take advantage of all of the rigs' normal features, including transmit offset and CTCSS encode/decode.

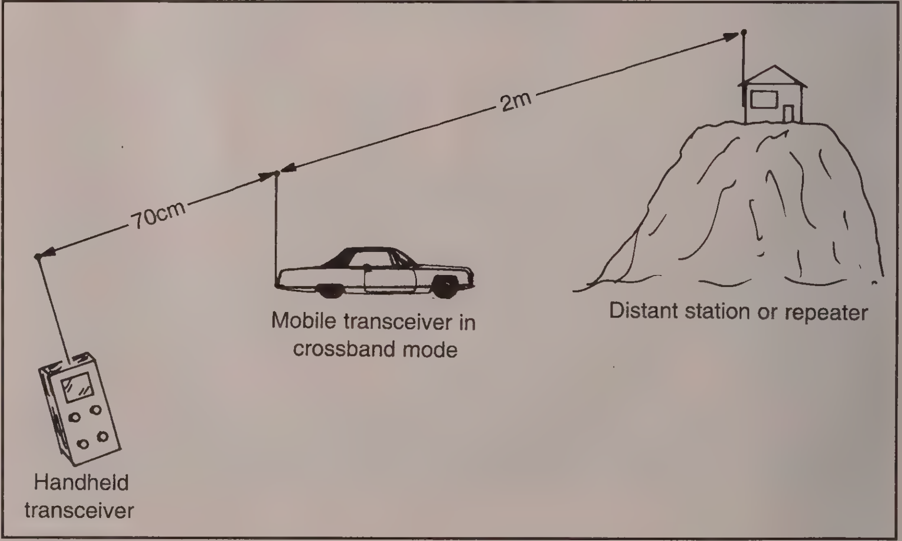


Figure 1. A system diagram that shows how a dualband mobile transceiver in crossband repeat mode can extend the range of a handheld radio.

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There are several reasons to use the crossband repeat feature. Probably the most common use is to extend the range of a handheld radio, as shown in figure 1. In this example, the handheld radio is set for simplex operation on the 70 cm band and the mobile transceiver is set to crossband from the same 70-cm simplex frequency to a 2-meter frequency. The distant station operates simplex on the same 2-meter frequency. I've arbitrarily shown the handheld radio on 70 cm and the other station on 2 meters, but there is no reason why the bands couldn't be swapped.

Another common use for a crossband radio is to fill in radio coverage gaps, perhaps on a temporary basis for a special event or emergency. For example, an ARES team might have trouble maintaining radio contact in a narrow canyon. Careful placement of a crossband rig can help fill in the gaps. Another common example is operating from inside a building where the radio waves don't penetrate very well. A crossband repeater out in the parking lot can help boost the signal.

One application where the typical crossband rig *doesn't* work well is in use at a conventional repeater site. The receiver performance of these radios may not hold up in an environment with strong interfering signals present. Also, these rigs are not really intended for heavy-duty, long-term repeater use.

Warnings and Tips

There are a number of things to watch out for when using crossband repeat. You need to be careful when selecting a frequency to avoid interfering with other radio amateurs' operation. There is no simple recommendation here, but understanding how the VHF/UHF bands are used in your area is the key. Check your local band plan to find a suitable spot and carefully listen for other activity. You may find that the band plan has a specific frequency designated for crossband repeat operation. Otherwise, you'll probably need to choose a lightly used set of simplex frequencies, one that conforms to the band plan.

Amateur VHF/UHF transceivers usually are designed for low duty cycle, with a mix of transmit and receive. They are not intended to transmit for long periods of time, so you need to take steps to keep the crossband transceiver from being continuously keyed at full power. One obvious thing to do is to set the transmit power to a lower level, which decreases the heat generated by the transmitter. This is especially true for radio links that only need to go a short distance (e.g., the handheld to mobile link in figure 1). Most of these transceivers have a transmit timer, which should be set to a reasonable time limit, say 3 minutes. If possible, using CTCSS decode on receive is highly recommended, as this can prevent unexpected signals from activating the transceiver and keeping the transmitter on.

We'd like to be able to access conventional repeaters using the crossband repeat function, but it might be a little trickier than you expect. Referring back to figure 1, suppose the distant station is really a repeater we want to access on 2 meters. Of course, we need to program the 2-meter transmitter in the crossband radio with the right tone and offset to access the repeater. Whenever the repeater transmits, the crossband radio will hear the 2-meter signal and repeat it on 70 cm. The 70-cm transmitter stays on until the repeater drops, so the crossband radio will not hear anything on the 70-cm side during that time. In other words, the crossband radio gets locked into repeating 2 meters to 70 cm and won't open up until the repeater stops transmitting.

Many amateur radio repeaters keep the transmitter on for 5 seconds or so after the user stops transmitting. If other repeater users respond quickly, the repeater transmitter may not drop during the contact. If there is an active net, or just some long-winded ragchewers, the repeater transmitter could remain on for hours at a time. The handheld user (figure 1) will be listening on 70 cm waiting for a chance to break in, but it may never come. This is a serious limitation of the crossband approach. It requires the signal from the other side of the radio to go away before the crossband repeater can switch direction, enabling a response.

This same principle keeps crossband repeat from being used to access the autopatch function on a repeater. As soon as the autopatch is turned on, the repeater will be transmitting the phone-line audio for the user to hear it, which will lock up the crossband transceiver.

You can probably think of other ways to use the crossband repeat mode. Referring again to figure 1, sometimes the handheld radio user can hear the distant station or repeater just fine but does not have a strong enough signal to get back to it. One approach is to have the HT listen to the distant station directly and only use the crossband repeat when it transmits. This requires a dualband handheld, since it will be listening on 2 meters and transmitting on 70 cm.

Photo B. Handheld radios are "handy," but they can often use a signal boost from a crossband mobile radio. (Photo courtesy <rigpix.com>)

Another approach is to have both stations use dualband radios to transmit on 70 cm and listen on 2 meters. This means that the crossband repeater is always listening on 70 cm and transmitting on 2 meters, much like a conventional repeater but with transmit and receive on two separate bands.

Control Point

For radio amateurs in the U.S., there are some FCC regulations that we need to adhere to when using a crossband radio. This quickly takes us into the realm of armchair lawyer, which is always a tricky place to be. I'll outline a few issues that I see in the FCC Part 97 regulations, but you'll be the judge of how you are going to handle them.

Like all amateur radio stations, the crossband rig must have a control operator and a control point for the radio. The FCC regulations (Part 97.105) say, "The control operator must ensure the immediate proper operation of the station, regardless of the type of control." Most crossband rigs do not have the ability to be controlled remotely; you flip them into the crossband mode from the front panel and the radio stays in that mode until someone manually turns it off. You might

consider the radio to be *automatically controlled,* which is allowed for repeater stations and auxiliary stations. (Refer back to the Spring 2007 *CQ VHF* FM column "What is this Auxiliary Operation Stuff?" for more information on auxiliary stations.) The control operator does not have to be present at an automatically controlled station.

Independent of the type of control used, the important point is that the FCC does expect you to be in control of your radio, since you are responsible for its transmissions.

Identification

The other regulatory issue with crossband repeat mode is transmitter identification. There are two transmitters in the crossband repeater and both need to send their assigned callsigns consistent with the FCC's 10-minute rule (Part 97.119). Most dualband rigs do not have an identification feature included that can be used for crossband mode. One exception is the Kenwood TM-V71A, which has a 10-minute Morse code identifier that can be programmed with your callsign. (The radio also can do voice identification if the optional voice synthesizer is installed.) Unfortunately, Kenwood implemented this feature to transmit an ID every 10 minutes in crossband repeater mode, even if there is no activity on the channel. This is very annoying for practical use and will increase the probability of causing interference for other users on the frequency. (Most repeater systems are implemented to stay quiet when there is no activity on the input frequency.)

I'll assume that the crossband transceiver does not have an automatic identifier in use (which is usually the case). Referring back to figure 1, both transmitters in the mobile transceiver need to be identified. We'll assume that the mobile rig is under the callsign of the handheld user, so when the handheld user transmits the callsign, it will also be transmitted on the 2-meter crossband transmitter. That can take care of that transmitter ID. In the reverse direction, the distant station's callsign will get sent (might be a repeater callsign) and repeated on the crossband 70-cm transmitter. We already said the mobile transceiver is operating under the callsign of the handheld user, so this doesn't work out very well. Some people say that the callsign of the distant station is used to ID the 70-cm mobile transmitter, especially if that distant station is a repeater. Of course, this would require the agreement of the distant station and it effectively makes it responsible for the ID function. As an alternative, the handheld user could flip over to the 2-meter frequency and identify, which would be repeated on the crossband 70-cm transmitter. Clearly, this situation is not ideal.

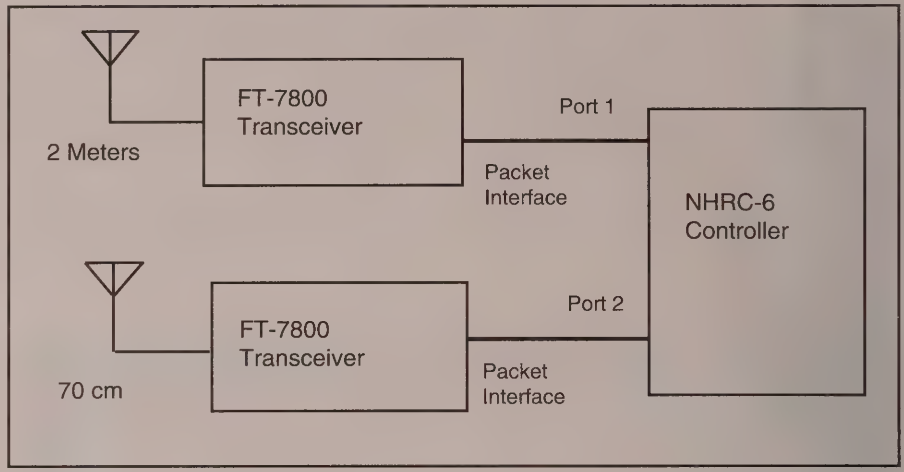

Figure 2. Block diagram of the two-transceiver crossband repeater.

Pin	Label	Description	Repeater Interface
1	PKD (Data In)	Packet Data Input	Transmit Audio
2	GND	Signal Ground	Ground
3	PTT	Ground to Transmit	PTT
4	RX9600	9600 bps Packet Data Output	—
5	RX1200	1200 bps Packet Data Output	Receive Audio
6	PKS (SQL)	Squelch Control	CAS

Table 1. FT-7800R packet port.

Crossband Repeater System

To deal with the issues of identification and control, I decided to use a repeater controller to control two independent 2-meter/70-cm transceivers. Most repeater controllers are set up for conventional repeater control with a fixed receiver and fixed transmitter. What I needed was a controller that incorporated the concept of two independent transceivers that could be linked together, independently controlled, and independently identified. The NRHC-6 Bridging Repeater Controller is designed to handle this specific case of connecting two transceivers. The block diagram of this crossband repeater system is shown in figure 2.

I used a pair of FT-7800R transceivers which have a packet port on the rear panel that provides a convenient interface point for the repeater controller. This port has the required transmit audio, receive audio, PTT line, and squelch line. The squelch line indicates the condition of the receive squelch, including the effects of CTCSS decode if enabled in the transceiver. (Not all transceivers behave this way; some only provide carrier squelch even if CTCSS decode is enabled.) Table 1 shows the signals available from the packet port and how they are used in the repeater interface.

The NHRC-6 controller has a versatile feature set that requires some programming to make it work. It supports two radio ports that can be configured to handle two back-to-back simplex radios. The controller has DTMF control, which can be accessed from either radio port. The five saved setups are handy for storing away specific repeater configurations. Each radio port can have its own courtesy tone and CW identifier, along with the usual set of hang timer, ID timer, timeout timer, etc. The crossband repeater can be turned on and off remotely using DTMF on either band.

Figure 2 shows two separate antennas, one for 2 meters and one for 70 cm. In most cases, I use one dualband antenna and a 2-

Photo C. The crossband repeater built using two independent FT-7800R transceivers controlled by an NHRC repeater controller.

meter/70-cm duplexer to allow the two radios to feed the antenna. I also keep the radios set at less than full power to minimize the heat-dissipation problem.

This crossband repeater is housed in a portable case that has standard 19-inch rack hardware (photo C). The two transceivers are mounted to a 19-inch shelf using their normal mobile mounts. The NHRC-6 controller has its own 19-inch rack-mountable chassis. The case has front- and rear-panel covers that snap on, protecting the equipment during transit. The system runs off 12 VDC. I did not include an AC power supply inside the case. Depending on the location, I simply connect the repeater to a 12-volt car battery or a compact AC switching power supply.

Tnx and 73

This has been an overview of using crossband repeating FM transceivers, along with an example of a more complete crossband repeater system. I hope this gets you thinking about how crossband methods can aid your radio operating. Thanks for taking the time to read another one of my columns on the "Utility Mode." I always enjoy hearing from readers, so stop by my blog at <http:// www.k0nr.com/ blog> or drop me an e-mail.

73, Bob KØNR

References

1. FCC Part 97 Rules
2. <http://www.arrl.org/FandES/field/ regulations/news/part97/>
3. NHRC Repeater Controllers: <http: //www.nhrc.net/>

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Amateur Radio Satellite Meetings

I spent the last half of the month of July 2008 attending amateur radio satellite meetings. First came the Amateur Radio on the International Space Station (ARISS) Face-to-Face Meetings in Moscow, Russia, and second was the annual AMSAT-UK Space Colloquium at the University of Surrey in Guildford, UK. This was my first-ever trip to Russia and the most recent of several trips to the AMSAT-UK Space Colloquium. I will attempt to relay my impressions and knowledge gained during these meetings in the following paragraphs.

ARISS Face-to-Face Meetings

Over the years, ARISS has held at least one face-to-face meeting in addition to the regularly scheduled telephone conferences and e-mail activity utilized to conduct the day-to-day business of ARISS. These meetings give the ARISS international delegates and others a chance to meet one another and conduct discussions, etc., that are difficult to do without the free exchange in a face-to-face setting. Typically, these meetings are held in conjunction with other amateur radio satellite meetings such as the annual AMSAT-NA Space Symposium and the AMSAT-UK Space Colloquium. Occasionally, the ARISS Face-to-Face Meeting is held independent of other meetings. The meeting in Russia was originally planned to take place near the time of the 50th anniversary of the launch of Sputink I on October 4, 1957.

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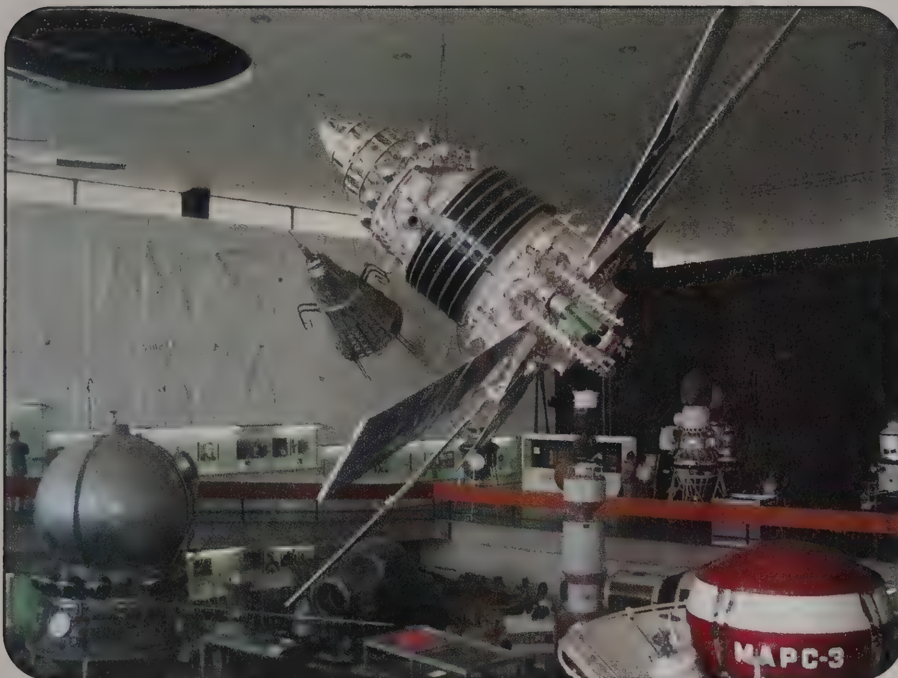
Sergy Samburov, RK3DR, and his famous great-grandfather, K. E. Tsiolkovsky.

Sputnik-1 opened up for access to payloads at the Space Museum of the Energia Corporation.

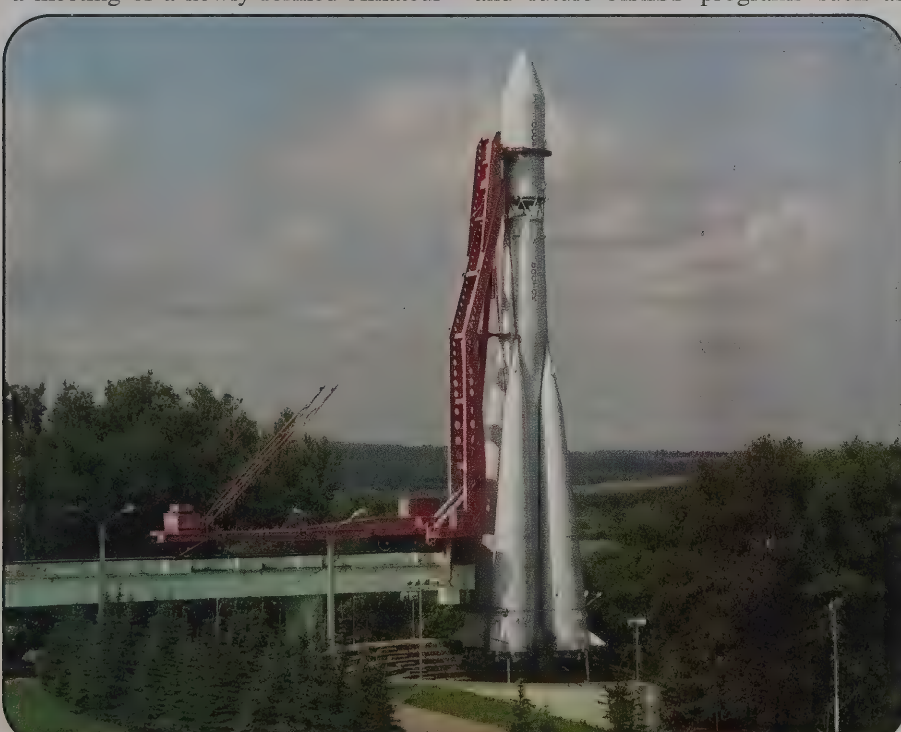
K. E. Tsiolkovsky and his "Ear Trumpet."



Space hardware in the Kaluga Museum.

Due to the planning and logistics involved in arranging such a meeting, it was nearly a year late.

This was actually a series of meetings involving several different aspects of the ARISS program. In addition to the core ARISS International meeting, there was a meeting of a newly formed Amateur Radio Working Group—a group of delegates made up of selected representatives of the various space agencies involved in ARISS. There were also meetings of the people involved in crew training relative to ARISS and Technical Interchange Meetings to discuss current and future ARISS programs such as SuitSat II. These meetings were held in a combination of NASA leased facilities in the hotel at which we stayed, the Energia Corporation Moscow facilities, and the Gagarin Crew Training Center in Star City, Russia.



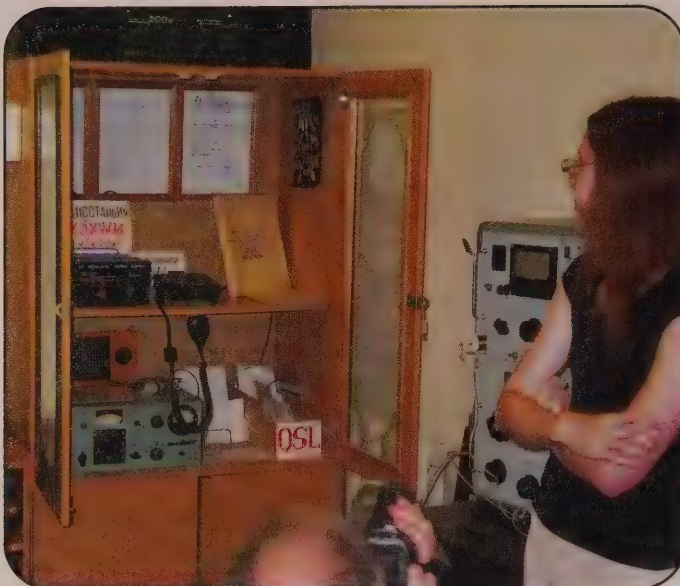
Full-size model of a Soyuz vehicle and its launcher at the Kaluga Museum.

We were also able to tour the excellent Space Museum at Energia Corporation. Many examples of actual space hardware were available to look at in this museum. Some actual hardware was available, along with test articles, spares, etc.

I was able to attend the ARISS International core meeting and the technical interchange meetings. At the ARISS international meeting held in the hotel, most of the delegates were present, but those who were not were tied in by teleconference and e-mail. Reports were given by each country or region represented on their activities over the past year. Status of the equipment currently on board the ISS was discussed. Plans for this equipment in the future, including updates, were spoken about. With the addition of more modules to the ISS comes the possibility of expanding station functions and increasing activity with more crew members present. Current thinking on these potential expansions and upgrades was discussed.

Technical Interchange Meetings were held the following week at Energia Corp. A principal focus of these meetings was for all parties involved to better understand the SuitSat II project. Some limited hardware was available for fit check into a genuine Russian Orlon Suit, and measurements were taken for making up cabling between the equipment inside the suit and the antennas and control box on the exterior of the helmet. Plans for the expanded functionality of SuitSat II were discussed, including location of solar panels for battery charging and interfacing of experimental payloads. Two representatives from a Russian university were present to discuss their proposed payload. With increased functionality, renewable power source, and experimental payload capability, SuitSat II will become a full-fledged amateur radio satellite, not just a neat publicity trick. It will fulfill a very valuable educational and inspirational service, as well.

Of course "all work and no play makes Jack a dull boy" came into play, and a weekend train trip to Kaluga, Russia, about 125 km southwest of Moscow, was planned by Sergy Samburov, RK3DR, the Russian ARISS International representative. The process started with a



RK3XWM amateur radio club station at the space school in Kaluga.

learning experience in the Moscow Public Transportation System, obtaining tickets for the Kaluga trip, and visiting a new, up-to-date shopping center for a first-class dinner. Kaluga is Sergy's home town and the town in which his famous great-grandfather, Konstantin Eduardovich Tsiolkovsky (1857–1935), lived and taught in most of his life. Kaluga is justifiably proud of K. E. Tsiolkovsky, Father of Manned Space Flight Theory, and has preserved many mementos of his career in his home, erected several memorials to him, and hosts an excellent space museum in his honor.

The highlight of the visit to Kaluga was the going to a special space school in Kaluga, where "hands on" techniques are used to introduce math, science, and other space-oriented disciplines to young students. While there, we were able to see a presentation about the school, models the students had made, their amateur radio club station, and also witness model rocket launches. We were able to meet a number of the students and the faculty.

Sergy and a picture of his great-grandfather in Sergey's original home in Kaluga.

Listening for DO-64 at the AMSAT-UK Space Colloquium.

My impression of Russia after this trip is drastically different from the Cold War days image I had in my head. Russia has indeed joined the western world in goods, services, and prices. There are still remnants of the old Russia around, too, as evidenced by the bureaucracy that abounds everywhere.

Additional information about the ARISS program can be found at: <http://www.ariss.org>.

AMSAT-UK Space Colloquium

Before my return to the U.S., I stopped in London and traveled to the University of Surrey for the AMSAT-UK Space Colloquium. This was an opportunity to renew old friendships from "the other side of the pond," make some new acquaintances, and catch up on the latest amateur radio satellite technology. The AMSAT-UK Space Colloquium still creates the feeling that you are back in school. Campus facilities—including meeting rooms, residence halls, and dining halls—are used for all activities. The British put on a good show and complete coverage of presentations, etc., is available at <http://www.uk.amsat.org>.

Highlights this year included an excellent presentation on the Delfi-C3 program by the Delfi-C3 Team, and the AMSAT-DL presentation by Peter Guelzow, DB2OS, on the Phase IIIE program.

The Delfi-C3 Team led us through the design, development, construction, and test of their triple CubeSat, now known as DO-64. Of particular interest to me was the presentation on developing and testing the mechanism for deployment of the antennas after launch. In the evening, following the presentations, we were able to witness the first pass, in range of the UK, with the DO-64 Mode U/V transponder active in amateur radio service. This satellite, like AO-07, is only useful if the satellite is in sunlight. There are no batteries in the satellite and operation relies on sunlight on the solar panels.

Return to High Earth Orbit (HEO) continues to be a dream of all satellite operators. We have been starved for HEO activity

Full-size model of Delfi-C3, DO-64, roughly 4" × 4" × 12".

since the untimely demise of AO-40. Peter, DB2OS, President of AMSAT-DL, gave a presentation on the status of the Phase IIIE program. In a nutshell, Phase IIIE is complete and ready to launch except for delivery, installation, and integration of the latest version of the Integrated Housekeeping Unit. This unit, an AMSAT-NA responsibility, is near completion but has been plagued by U.S. ITAR problems. ITAR governs release ability of technology developed in the U.S. to other countries. This is complicated by the fact that AMSAT-DL is running out of funds to keep its laboratory open for business until the "bird" is complete.

Now for an even bigger problem: No affordable launch has been found to date. Launches are available, but none of the AMSAT units alone or in combination have been able to come up with the funds to launch the "bird." AMSAT-DL continues to look and negotiate, but so far these efforts have borne no fruit. There is still hope that some help will become available if the German government decides to fund the AMSAT-DL Phase 5A program, but don't "hold your breath."

Summary

This column reported on the activities at a couple of amateur radio satellite meetings. Attend and support these meetings whenever you can. The next one is the AMSAT-NA Space Symposium, which will be held in Atlanta, Georgia, October 24–26, 2008. It will be over by the time you read this, but you can start now to plan for next year's meetings.

Don't forget to support AMSAT in its education and fund-raising efforts so that we can continue to put more "birds" in the air. In particular, support Phase IIIE, Eagle, and the Intelsat Phase IV Ride Share projects so that we can get back into the HEO satellite business.

'Til next time! 73, Keith, W5IU

By John Champa,* K8OCL

New High-Speed Multi-Media Radio Mesh Networking

If you have not been tracking the events of the North Texas Microwave Society (ntms-hsmm@yahoogroups.com) on the HSMM web page, you are missing a lot of action! The NTMS is in the heart of wireless Telco development country in the Dallas/Plano area. New developments and innovative thinking are taking place all the time.

de KD5MFW

For example, recently I had an opportunity to interview Glenn Currie, KD5MFW, who is working with a team of HSMM radio experimenters in the Round Rock (Austin), Texas area. This team is called the Austin HSMM Special Interest Group (SIG). There are some key participants from the Roadrunners Microwave Group (RMG).

An interesting development Glenn reports is that by using Optimized Link State Routing Protocol (OLSR) their new mesh nodes auto link and are passing data within five seconds of coming into RF range. For more information on OLSR, go to <http://www.olsr.org>. With a large mesh, when two nodes are passing data and a node in the link goes down, OLSR automatically switches to another route through the mesh. The user usually notices nothing. This development puts HSMM on the cutting edge of mesh networking!

Figure 1 is a web page served up from inside the WRT54G router running the Austin HSMM SIG version of the OLSR mesh software. Under "Links" are shown all the current nodes within RF range. These nodes include node 71, which is serving up the web page (10.1.71.1:1978). Port 1978 is the OLSR status port address for each node.

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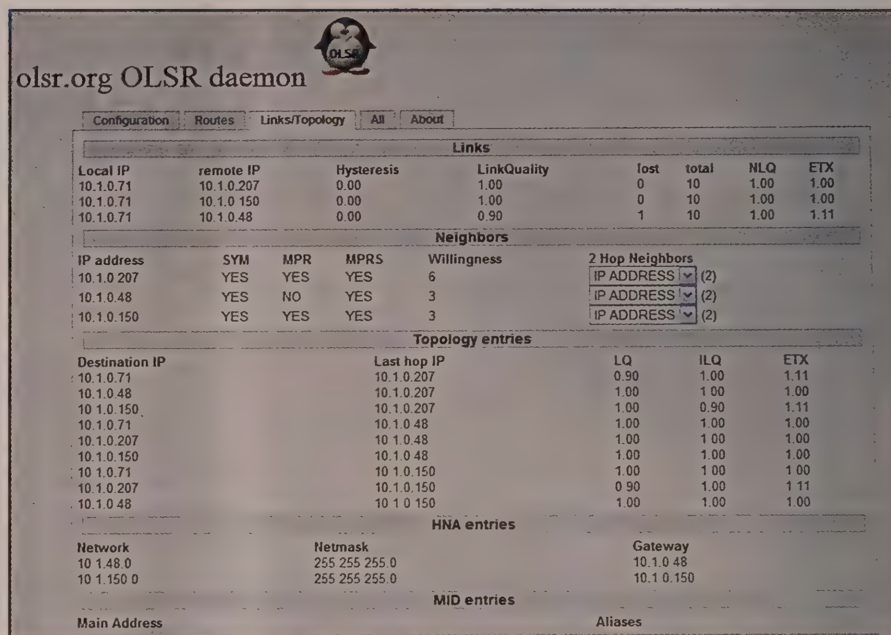

olsr.org OLSR daemon

Configuration | Routes | Links/Topology | All | About

Links

Local IP	remote IP	Hysteresis	LinkQuality	lost	total	NLQ	ETX
10.1.0.71	10.1.0.207	0.00	1.00	0	10	1.00	1.00
10.1.0.71	10.1.0.150	0.00	1.00	0	10	1.00	1.00
10.1.0.71	10.1.0.48	0.00	0.90	1	10	1.00	1.11

Neighbors

IP address	SYM	MPR	MPRS	Willingness	2 Hop Neighbors
10.1.0.207	YES	YES	YES	6	IP ADDRESS (2)
10.1.0.48	YES	NO	YES	3	IP ADDRESS (2)
10.1.0.150	YES	YES	YES	3	IP ADDRESS (2)

Topology entries

Destination IP	Last hop IP	LQ	ILQ	ETX
10.1.0.71	10.1.0.207	0.90	1.00	1.11
10.1.0.48	10.1.0.207	1.00	1.00	1.00
10.1.0.150	10.1.0.207	1.00	0.90	1.11
10.1.0.71	10.1.0.48	1.00	1.00	1.00
10.1.0.207	10.1.0.48	1.00	1.00	1.00
10.1.0.150	10.1.0.48	1.00	1.00	1.00
10.1.0.71	10.1.0.150	1.00	1.00	1.00
10.1.0.207	10.1.0.150	0.90	1.00	1.11
10.1.0.48	10.1.0.150	1.00	1.00	1.00

HNA entries

Network	Netmask	Gateway
10.1.48.0	255.255.255.0	10.1.0.48
10.1.150.0	255.255.255.0	10.1.0.150

MID entries

Main Address	Aliases

Figure 1. ARES-MESH status screen as displayed by mesh node 71 by looking at address 10.1.71.1:1978 using a web browser. Three other nodes can be seen with good link quality.

Moving to the right on the top section, local node 71 can see remote nodes 207, 150, and 48. There is no delay (hysteresis) set. RF link quality between all nodes is "perfect = 1" except for node 71, which has a less than perfect, but usable, link to node 48, and thus the 0.90 rating. It looks as if that 0.90 link quality was because one packet was lost out of the last ten (but was resent and correctly received). Therefore, the net link quality to all nodes is perfect = 1.00, because no data was lost, although a resend was needed from node 48. The next group of data shows an IP address that node 71 can see. SYM, MPR, MPRS explanations will not fit in the caption.

Willingness shows the number of possible ways a node has to get to other nodes. Two Hop Neighbors show the IP address of the two different hops a node can make to other nodes. You have to click on the down arrow to see the addresses. In a big network the list would be huge.

The Topology entries show all combinations and permutations of links between nodes in the network: LQ, ILQ, and EXT all are measures of link quality.

Link quality is important for such things as Voice over Internet Protocol (VoIP). If the link quality is poor, you may be able to sputter files through without errors, but there will be dropouts for VoIP or video. No user intervention is needed to link with the mesh. This is why it is good for the field—no messing with addresses in the field. Exciting stuff! I will report more details on that in the next column. I also will try to strike a careful balance between giving recognition and at the same time protecting developers' time by preventing them from getting swamped with questions, which could interfere with their part-time work.

It appears that the Austin HSMM SIG is way ahead of what most other groups are doing in HSMM. John, N5OOM, and

the crew in the North Texas Microwave Society HSMM SIG have done a lot of good work, and John's presentations are well done and informative. Some of that material has been published here, and I highly recommend it to people interested in HSMM. However, nothing has been published yet about crystal modifications to the WRT-54G or making serious modifications to the firmware. We are looking for material on those subjects.

Glenn promotes HSMM for several reasons. Hams need to make use of the inexpensive WiFi gear that can easily be operated on the ham bands and get into broadband computer-based radios. Hams need to be active in this or the hobby will fade. It is related to what the younger tech folks are doing with the internet.

Glenn grew up with computers and radios. He has one foot in each camp, as do all the key developers he is working with. That puts them in a position to have just the right perspective to see the great value of HSMM and how it needs to come together. Glenn has a 16-GB USB thumb drive on a lanyard that he carries around with him. It is full of academic papers related to the U.S. Department of Defense's Defense Advanced Research Projects Agency (DARPA) and other robot and communications topics, and the material they have collected on their HSMM projects. I hope to convince him to publish some of that material in future columns.

Years ago Glenn worked for the McDonald Observatory associated with the University of Texas and had one of the early ARPANET e-mail addresses. That was 25 years ago, and he has worked with the early 4.1 BSD Unix on a VAX11780. After tinkering with Unix/Linux systems for 25 years, you can't help but pick up a few things.

Glenn is a founding member and on the board of directors of The Robot Group Inc., a non-profit technology corporation for building stuff they won't let them build at work. He was also a team member of the Austin Robot Technology autonomous SUV entered in the DARPA Grand Challenge, having a vehicle drive 130 miles through open country with absolutely no human intervention. They did not win, but their "Marvin" was competitive. He had access to and interest in DARPA information for a long time, and as the ARPANET morphed into the internet, it is much easier to follow trends in robotics and communications. Glenn blasts through many published papers each week—anywhere from 30 to over 100. Commercial and military folks have been using mesh technology for some time and are still refining significant details. Glenn tries to follow what they publish:

I have been pushing for integration of 802.11 wireless technology into our emergency ham radio stations at area hospitals since 2002. This is called the ARCHES project. I am lucky enough to have some very capable friends who are interested in HSMM and they have done a lot of the development work, so it is truly a group effort. I serve as the "spark plug" and evangelist for the project. The project stays interesting, as we are learning new things all the time.

We have a wealth of information we have collected for 5 years or more of development. I have given a handful of presentations to key groups in the Austin area. Austin is the state capital, and as such, there are some hams high up in a number of the big agencies and large high-tech companies in the area. This has provided offers of microwave sites that we need to make the project work. We don't have the funds to rent space like the cell phone companies can. The strategy has worked well.

Glenn recognizes the need to get hams up to speed on what they have done so far, and they have a specific planned deployment to demonstrate it to potential ARES served agencies so they can understand what they can and cannot do with the system. It can be of great use, but explaining it, even to most hams, is more of an education and not an explanation. The administrators of the served agencies need to understand the capabilities of the system *before* they are in the middle of managing a particular disaster response:

We started our HSMM efforts to link area hospitals that already had ham stations in them, with faster links and to free up the 2m/70cm 1200-baud packet traffic frequencies for hams coming in from Llano, Taylor, Luling, etc., where the propagation of 2m/70cm was well suited for the distance they were trying to cover.

We have a great mix of skills and experience! The Roadrunners Microwave Group historically has been oriented toward conventional high-power narrowband modes—e.g. CW. Therefore, the group is well versed in stretching the distance and is essentially used to/from a mesh stand point, doing long-distance, point-to-point fixed and mobile links. They include a bi-directional amplifier (BDA) in their systems as standard operating procedure. However, the Austin HSMM SIG, part of the Travis County ARES (TCARES), found little use for BDA amps around Austin.

Either you had good locations or not and unless your amp was powerful enough to burn a hole through obstructions in the path, it did little good. Our anchor station at the Chapter Red Cross building in Austin is on a tower that needs maintenance. We have a lot of stuff on the tower and the rotor for the main beam needs replacing, as well as feed lines and about a dozen smaller antennas. It has finally cooled off a bit, so the tower work can be done without frying the tower workers. (*Editor's note:* It gets extremely hot in Texas in the summer and that must be taken into consideration when planning to do any antenna work!)

The American Red Cross is working off loans to operate now and needs donations. They did all they could to help during Hurricanes Katrina and Rita and they went more than broke helping in these disasters. So we need to do what we can to help with the tower there, as they are living on credit at the moment.

Hurricane Ike was handled differently and ham radio involvement was limited. The participation of the Red Cross was different as well. All of the background-check stuff is causing hams who have worked maintaining Red Cross and Emergency Operations Center (EOC) ham shacks to tell the agencies to "shove it" when after decades of service, they are being treated like criminals. Therefore, more of the work is done by hired hands with minimal background checks.

When I worked for the McDonald Observatory, my office mate on the UT campus in Austin went to work for the NSA. They did a background check. This stuff of the Red Cross and other agencies is more a cynical attempt to put a sub-contractor between them and any liability of a worker having a criminal history.

Over 20 years ago, the NSA spent over $20,000 checking out my office mate. The Red Cross spends $7 on a "background check." Apples and oranges or whatever—it is fruitcake to compare the two, and terribly misleading. I "throw rocks" as much as anybody, but I feel it is important to try to then close the loop and figure out what can be done to help, after all the dirty cards are on the table.

Anyway, we are looking into setting up HSMM stations for shelter logging, on a somewhat expanded scale of how we have used HSMM to do Field Day logging for the past three years.

The idea is that we drop off the HSMM gear at a shelter, get it on line, and then clear our potentially criminal butts out of the shelter and just collect the data over the mesh network. This circumvents us being physically present at the shelters, except to set up the gear. We never have enough hams to man 60 shelters 24/7 for days on end anyway, but we could make a go of it with HSMM mesh links between shelters.

We hope to set up a few demos of the con-

Photo A. The AeroComm 900-MHz, 1-watt modem.

cept with links between some of the most often used shelters in the area and invite potential served agencies to see what we can do, if allowed to deploy the gear. We have to demo the gear so we are part of the plan ahead of time. Once a disaster is under way, you cannot bug the administrators with new experiments; they have to go with what they have. Hopefully something will come of the demo effort, as ARES disaster support for served agencies has really changed as of Ike.

Thanks to Glenn, KD5MFW, and the RMG, I will report more on the Austin HSMM SIG next time and their cutting-edge mesh networking breakthrough! You will find their amateur digital video (ADV) and VoIP telephony experiments especially interesting.

de KB9MWR

Steve Lampereur, KB9MWR, of Green Bay, Wisconsin, reports that with the AeroComm 900-MHz, 1-watt units (photo A) his team has observed solid non-line-of-sight mobile coverage for 3 miles. This is with a base station at 35 feet into a 6-dBd omni antenna and a magnet-mounted antenna on the car. There is mobile coverage up to 6 miles, but it is not as solid.

The AeroComm CL4490-1000 ConnexLink is a 1-watt, 900-MHz Frequency Hopping Spread Spectrum (FHSS) RS-232 transceiver. The individual transceiver is available from Mouser Electronics (Part No.: 814-CL4490-232-C) for approximately $110 (http://mouser.com/>. Experimenters may wish to pick up the starter pack, which includes two transceivers, software, cables, and rubber-duck antennas (Part No.: 814-CL4490-232-SP) for approximately $225.

The actual RF module itself (AC4490) can be bought for $62 (Part No.: 814-AC4490-200M). The complete AeroComm CL4490 transceiver includes the AC4490 module housed in a nice aluminum case with an internal switching power supply and the necessary RS-232 to TTL conversion circuit. The antenna connection is via a Reverse Polarity SMA (RP-SMA). The CL4490 also includes four handy LEDs, which indicate DC power (PWR), link establishment (LINK), when it is receiving (RX), and when it is transmitting (TX).

Digi-Key (www.digikey.com) sells a handy "SMA Reverse Polarity Plug to SMA Jack" (Part No.: ACX1248-ND) adapter, which changes the CL4490's reverse polarity SMA connector into a normal SMA connector. To obtain specific details on network configuration go to: <http://www.qsl.net/n9zia/aerocomm>.

Until then, keep doing those radio experiments!

73, John, K8OCL

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Ultra Wide Band (UWB)

We certainly are seeing a lot of articles these days on Ultra Wide Band, or UWB. The FCC has set aside 3.1 GHz to 10.7 GHz for UWB use. There is a lot of bandwidth and there are a lot of challenges for both transmitters and the antennas (photo A).

There are three main types of UWB signals being used at this time. The first type is simple FM. If I take my 5-GHz walkie-talkie and crank the FM deviation up to 500 MHz, this meets the FCC definition of UWB. No, that is not a typo. I didn't mean 5 kHz, but 500 MHz. Even the old C-band TVRO only used 30 MHz wide FM video. However, the idea is the signal is spread so thin that there isn't enough signal in any one part of the band to cause much interference. This is legal according to the FCC, but not commonly used.

The next UWB modulation is Orthogonal Frequency Division Multiplexing (OFDM). OFDM can be thought of as hundreds or even thousands of carriers each being separately modulated. It is kind of like one-thousand 9600-kb modems running in parallel. Thousands of these signals can result in data rates of over 250 Megabits/second. Demodulation of all these carriers is somewhat math intensive. However, with such little power in each carrier, again the interference potential is low. Also, to keep the FCC happy, the signals must be spread out over at least 500 MHz, and there are some complex formulas on how evenly the energy is spread out.

Impulse or Pulse Position Modulation was the original UWB modulation. The transmitter in photo A puts out a 1-watt pulse for 1-billionth of a second. This fast pulse isn't done with super-fast digital circuits, but rather with clever oscillator design. As the oscillator is turned on, the oscillator puts out five or six sine waves centered at 6 GHz and then shuts down as all the DC energy is used from the capacitors in the circuit. In many ways this is very similar to the self-squelching oscillators used in super-regenerative circuits for the last 90 years.

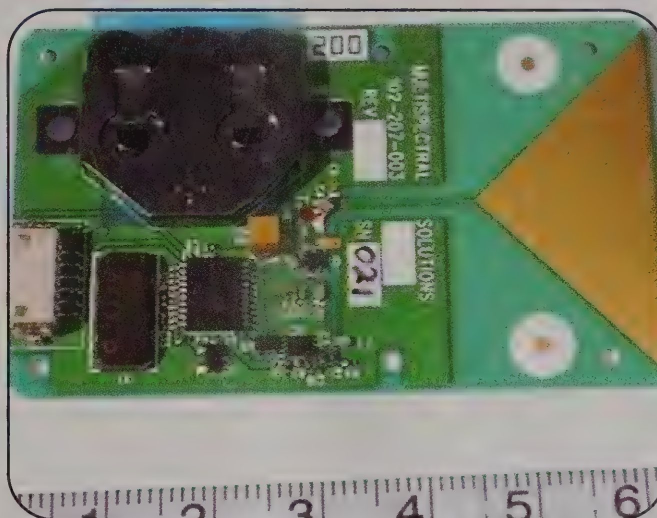

Photo A. Ultra-wide-band transmitter and antenna.

We had to use a Tektronix 11801 scope with a 26-GHz bandwidth to look at these fast pulses. The timing between pulses is used to send data. While the transmitter is putting out 1 watt, it has to transmit one-billion pulses to use up just one watt-second from the battery. That lithium coil cell will run the transmitter for over a year.

UWB Antennas

There are two big engineering problems with UWB antennas. The first is bandwidth; the antenna has to work over several GHz of bandwidth. The next problem is the Q of the antenna.

The typical resonant antenna is a high-Q structure. One way of looking at a high Q is to think of it as being similar to a flywheel that is spinning and spinning, thereby storing energy.

As shown in figure 1, on average, an electron must go back and forth on a dipole about 30 times before it leaves as an electromagnetic wave. Furthermore, it is only after the energy has built up on the antenna that it starts to look like 50 ohms. Back on 40 meters, this means that for the

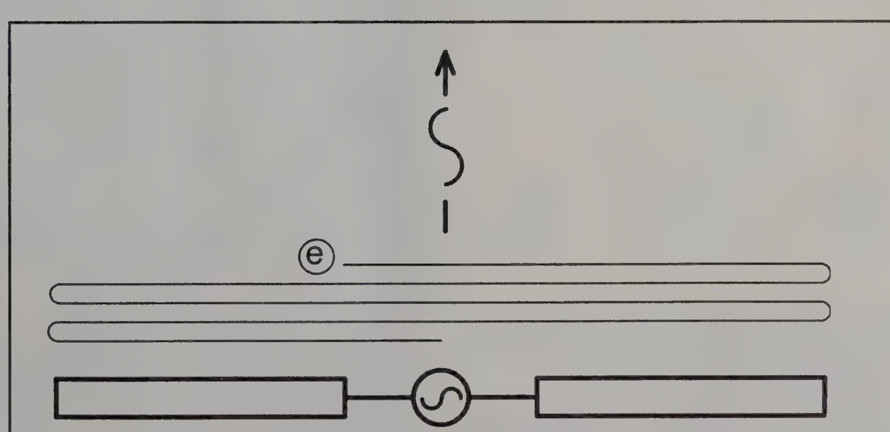

Figure 1. A typical electron takes 30 passes to radiate as a wave.

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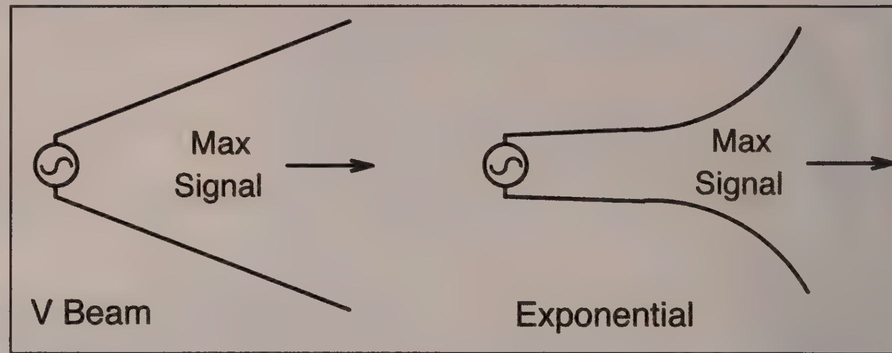

Figure 2. Dipole to V to Vivaldi antenna.

first 1/7,000,000 second your inverted-V looks like a dead short to your transmitter. Then, 1/7,000,000 second later the antenna has an impedance of a few ohms. Also, only after a few dozen waves have gone into the antenna does the voltage start to build up and it begins to approach the typical 50-ohm load. Of course, the average ham isn't all that worried that it takes few millionths of a second for the impedance of the antenna to stabilize.

However, for the designers of high-speed data networks and high-resolution RADAR systems, the transmitter impedance and the antenna impedance may be a lot different for these short pulses than it is for a CW signal. Also, the time it takes for the voltage to build up delays the pulse. Now my nice short pulse has been delayed by the ringing currents in the antenna, lengthening and delaying the data.

Exponential Antennas

If we start out with the simplest beam, we just take a dipole and point the elements forward, as in figure 2. Make the elements longer and longer, and the gain goes up. We now have the V beam, and when several wavelengths long, we start to build a rhombic antenna. On HF the ends of the wires are usually terminated with load resistors. However, if we make the wires thicker and thicker, we get a good SWR without the load resistors and build what is known as the Ram's Horn antenna. The Vivaldi antenna in photo B is from this same family of transmission-line antennas—a very wide bandwidth and modest gain, but unlike the dipole we don't have all that much circulating current.

Log Periodics

Because the log periodic is an array of dipoles, it also has the tendency to resonate and stretch out a sharp pulse. The log periodic in photo C covers 2 to 11 GHz and the entire UWB band. Two years ago we used that same log periodic as the feed for a 12-inch dish and were able to collect data from that 6-GHz trans-

Photo B. Exponential or Vivaldi antennas.

Photo C. Log periodics and UWB.

mitter in photo A at over two miles. UWB is not necessarily a short-range mode.

Scimitar Antennas

The Scimitar antenna has a long history in both electronic warfare and as a telemetry antenna in the Apollo space program. The inner radius sets the high frequency, and the outer radius sets the low-frequency range of the antenna. The Scimitar in photo D has an excellent 400–1500 MHz bandwidth. From a practical side, the antenna has a natural input impedance of about 20 ohms, so some kind of 20–50 ohm matching network is necessary.

Furthermore, it is usually the bandwidth of this matching network that sets the bandwidth of the antenna. A simple Scimitar covering the entire UWB band is small, simple, and becoming popular on many UWB products. When I come up with a simple matching system a multiband Scimitar should make a good ham project.

Fractal Antennas

In photo E you can see my Stage 5 Sierpinski fractal antenna. There has certainly been a lot of hype about fractals, and claims about their use with UWB. On the right you see a triangle of copper the same size as the Sierpinski. Whether the antenna is on network analyzer, or in the field, there is no significant difference in their performance. As to filters, this filter flattened out at 3.1 GHz. Thus, UWB starts at 3.1 GHz with very strin-

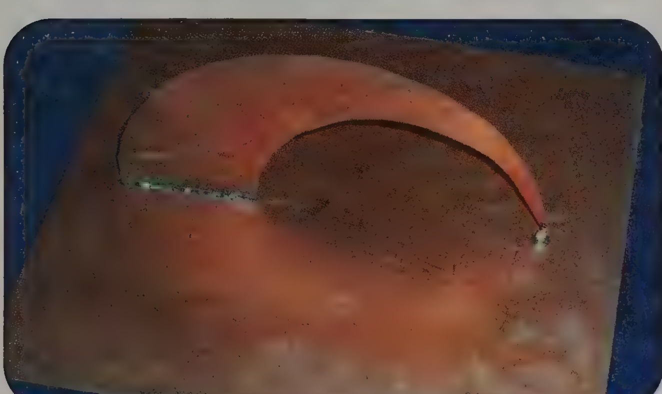

Photo D. Scimitar antenna.

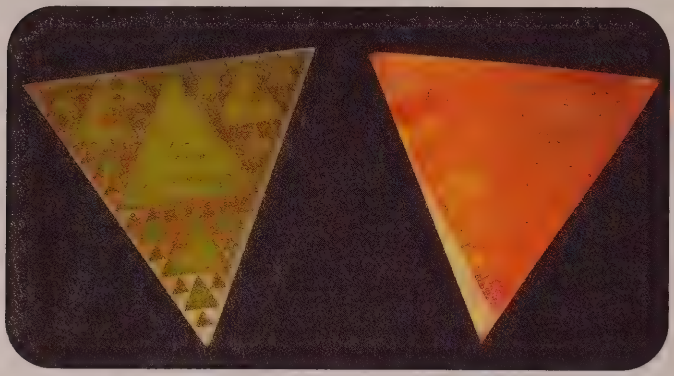

Photo E. Fractal antennas.

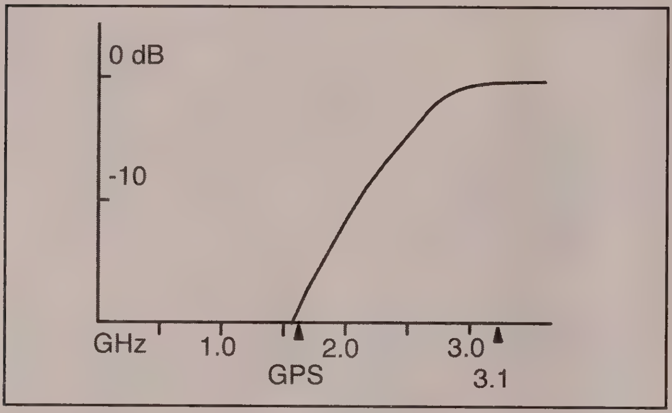

Figure 3. Gaussian response filter protecting GPS.

gent limits on how much signal/noise the UWB transmitter can put on the GPS band.

I always thought that the 3.1-GHz lower frequency limit for UWB was a kind of strange number. The early UWB systems were the impulse types. These short pulses on the order of one-billionth of a second long can make quite a racket. Some of the early UWB systems took out UHF TV, cell phones, and more importantly, GPS. Taking out GPS took out two major systems. First was navigation. For the FAA, this problem became a "safety of flight" issue.

The pulses also took out most cell-phone systems. A little bit of noise on the cell-phone bands just means your range drops a bit, and the battery in your phone gets used up a little faster since the phone has to run more power. However, the cell-phone problem went right back to the navigation problem. All those cell towers are kept in sync with the time signals from a GPS antenna on that same tower.

Without GPS, the cell sites lost sync. Therefore, the "experts" who said those short pulses would never bother anyone did not agree with the field work that showed impulse UWB chew up and spit out a number of systems.

The FCC and FAA's first priority was to protect the GPS band around 1.575 GHz. You can't just put a Drake TVI filter on a UWB signal, because the filters mess up the pulse. Therefore, the engineers looked at a UWB-compatible filter with a notch centered at 1.575 GHz. A pulse gets rounded off and stretched out when it goes through a filter. Also, the "ringing" stretches out the pulse. Therefore, a simple high-pass filter is not going to fix these interference problems. However, there is a class of constant group delay, or Gaussian filters.

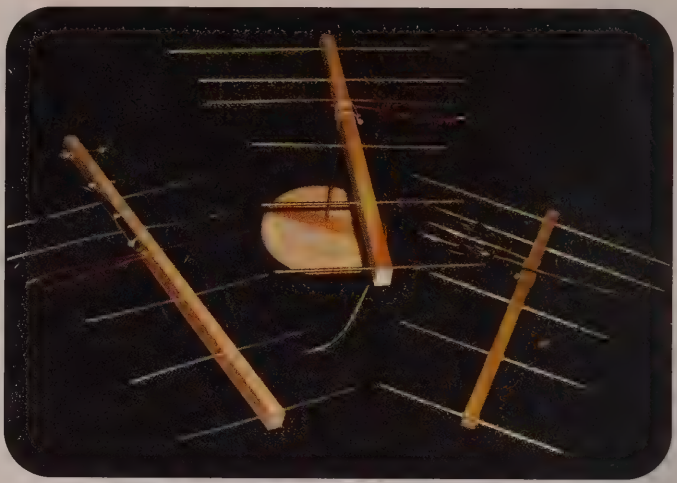

Photo F. UHF HDTV "Cheap Yagi."

These keep the pulse nice and square. Even so, Gaussian filters don't have a very sharp response.

In figure 3 we have a Gaussian filter with the notch right at 1.575 GHz to give maximum protection to GPS. The filter rolls off at 3.1 GHz. Now you know where that 3.1-GHz limit came from for the bottom of the UWB band. The upper limit is 10.7 GHz. Above that frequency are mainly military radars, and they don't like any competition.

Back to the experts who claimed that those high-power one-billionth of a second pulses would never bother anyone on the UHF bands: They missed several little things in the real world. First, most radios have some kind of filter in their front end. These filters again ring and lengthen out the pulses. The high-power UWB systems still have enough power through the filters to saturate the first transistor in the receiver. Now the power supply and bias supplies have to recover from this full-power whack, and this takes a few thousandths of a second. Of course, the pulse continues into IF, and IF filters lengthening out the pulse even longer. Now the pulses are long enough to blank out data, put bars on your TV set, or wipe out GPS systems and any cell towers on which they are located.

The HDTV Transition and Simple TV Antennas

If you subscribe to the other two magazines published by CQ Communications (*CQ* and *Popular Communications*), you know that I write for both of them as well as *CQ VHF*. It is because of the coming transition to digital television before my next *CQ VHF* column that I mention a construction article in *Popular Communications*. You will find a downloadable copy of the construction project for my HDTV version of the "Cheap Yagis" (photo F) at: <http://www.popular-communications.com/23-AntennasWeb92708.pdf>. Of course, a subscription to *Popular Communications* is the best way to go for this timely information, but CQ Communications has made a special exception to its embargo policy of current articles for this HDTV project.

As always, I enjoy your input and suggestions for future topics. You can e-mail me your antenna questions or suggestions at <wa5vjb@cq-vhf.com> and visit <http://visit www.wa5vjb.com> for additional antenna projects.

73, Kent, WA5VJB

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Superlaunch 2008

Each year many of the active amateur radio high-altitude-balloon groups across the nation attend the Great Plains Superlaunch (GPSL). This year's event was hosted by Near Space Ventures and CAPnSPACE and was held in the Kansas City area (see photo 1).

On Friday, August 1st, we gathered for an informative conference in a large auditorium at William Jewell College in Liberty, Missouri. This was an opportunity to discover what other groups have been doing and what they've learned in the past year. New payload designs and experiments, long-duration flight techniques, and multi-balloon linking as well as educational outreach efforts were among the topics covered. This year's program also included a unique K-9 search-and-rescue talk complete with live demonstrations of the search-and-rescue dog's ability to locate individual members of the audience using nothing but scent clues. They actually took the dogs into the field to track Near Space Ventures' payload during the following day's launch.

Launch Day

Near sunrise on Saturday we all gathered in a field near the college and started inflating a total of nine balloons (see photo 2). Due to the rising costs of helium, using hydrogen safely was a hot topic this year. Nick Stich, KØNMS, and Taylor U (KB9ZNZ) each launched hydrogen balloons this year just prior to the release of the helium-filled balloons.

The helium-filled balloons were then launched, filling the sky with nine balloons in the air at once (see photo 3). Nick, KØNMS, ended up flying two balloons which carried APRS as well as the Garmin RINO system (GMRS radio with GPS) and a beacon on 434 MHz. Edge of Space Sciences (AEØSS) flew APRS, a crossband voice repeater (VHF/UHF) that provided coverage over a several-state area, as well as live camera amateur television (ATV) on 426.25 MHz showing dramatic views from the stratosphere in real-time. Taylor University flew two

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Photo 1. Attendees at the Great Plains Superlaunch.

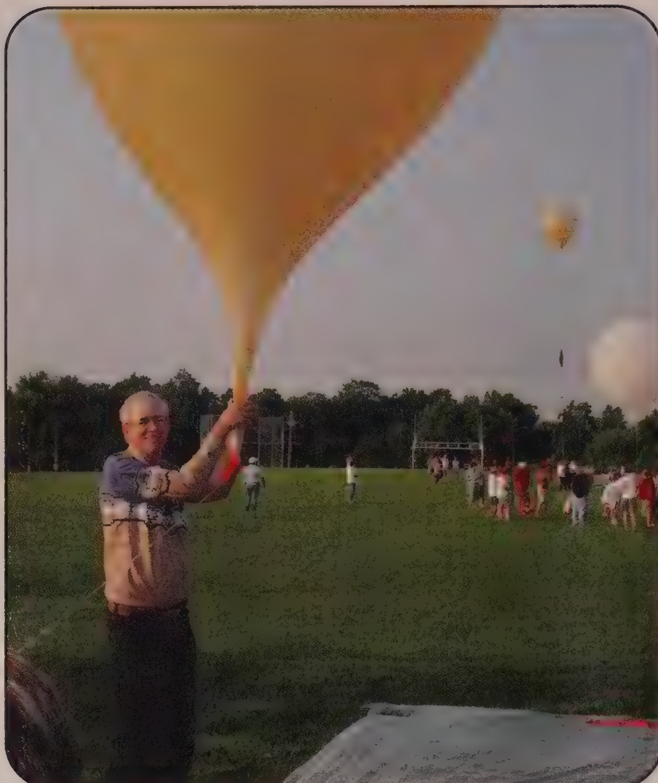

Photo 2. Jerome Doerrie, K5IS, gets ready to launch the WB8ELK balloon.

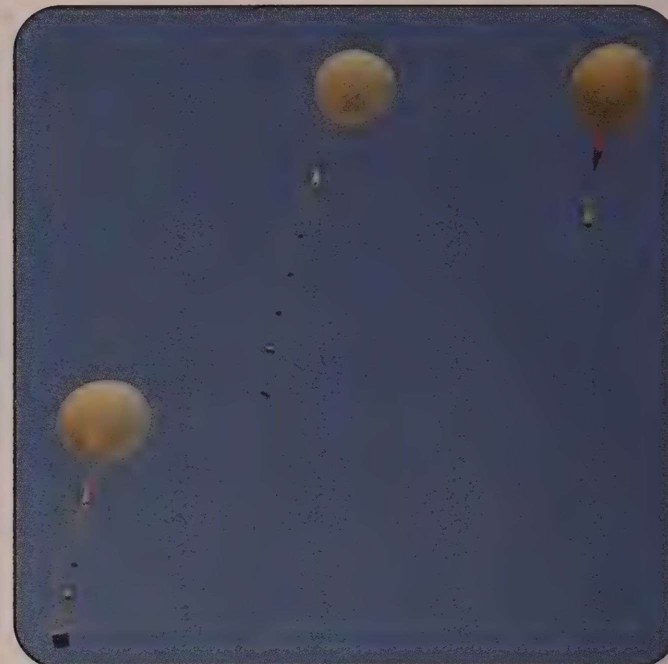

Photo 3. Balloon payloads fill the sky over Kansas City.

Photo 4. The WB8ELK payload is recovered from the tall grass. Left to right: Mike Bogard, KDØFW; Lynn Trotter; Bill Brown, WB8ELK; Florence Bower; Jerome Doerrie, K5IS; and Bobette Doerrie, N5IS

different balloons which carried APRS and a spread-spectrum 900-MHz system. BASE from DePauw University (W9YJ) flew APRS and a 900-MHz spread-spectrum system. ORB (KC5TRB) flew APRS as well as a 2-meter audio CW FM beacon and a 10-meter CW beacon. Near Space Ventures (WØNSV) flew a 2-meter APRS transmitter. WB8ELK flew APRS, a 2-meter simplex voice repeater, a 2-meter voice beacon, and a 10-meter HF telemetry transmitter sending down RTTY, Hellschreiber, and DominoEX5.

The Chase

With all these transmitters in the air at once, it was a fox-hunter's dream. After liftoff we jumped into our vehicles and headed out on a wild chase toward the predicted landing zone. The real challenge was to get there before our payloads parachuted back down from the stratosphere. Fortunately, most of the payloads landed in a rural area south of Kansas City. One of the Taylor U balloons had a vent valve on it, and it came down with the balloon intact. When their chase team found it, they cut off one of the payloads and sent it up once again for a second flight on the same balloon. This proved to take a very long time to reach burst altitude, staying up for hours and traveling about 100 miles downrange into the Ozarks. The rest of the balloon payloads landed within a few miles of each other, some in trees and others in open fields.

My team was about two miles away when our payload landed, and we could hear the beacons and voice repeater as we closed in on the area. We drove down a new road in a future housing development and heard a very strong signal. Waist-high grass covered the fields on either side of us as we drove up and down the road in hopes of spotting the bright neon orange and yellow parachute. After wandering up and down the road for a half hour, Mike Bogard, KDØFW, and Lynn Trotter arrived on the scene with their direction-finding (DF) equipment. Mike got a fix on the 434-MHz CW beacon and pointed the way while Lynn ran out into the field and found it just 20 feet from the road buried deep in the tall grass (see photo 4).

After tromping around fields and climbing trees in 100+ degree weather, we all were happy to cool our heels at the victory dinner to swap tales of our many adventures and plan for another fun time next year.

Next year's Great Plains Superlaunch (GPSL 2009) will be held the first weekend of August near Lawrence, Kansas (www.superlaunch.org).

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Sleeping on the Job . . .

Perhaps you've heard the speculation that our local star is in a coma. Not only amateur radio operators, but now the general press, are picking up the solar buzz, wondering out loud if the sun is in hibernation with a seemingly longer than usual solar cycle minimum. Where are the sunspots? Where's the activity of a new solar cycle? "We're going to see another Maunder Minimum and a mini-ice age!"

Really? The Maunder Minimum occurred during the period starting in 1645 and ending in 1715, an incredible 70 years during which sunspots were rarely observed. To the observer, this period is void of any evidence of 11-year solar cycles. What's more, this period coincided with the famous "Little Ice-Age," a series of extraordinarily cold winters occurring in the Northern Hemisphere. Is a new Maunder Minimum unfolding on our watch?

A fair amount of chatter developed during August 2008 because it was the first time since 1913 that there was a month or more between sunspot appearances. Certainly, it stood out as unique because it was the first time that a whole calendar month went by without observed sunspots. In a practical sense, however, this is not that remarkable; calendars mark arbitrary beginnings and endings, and a 30-day period occurring at any time is just that—30 days without sunspots. Also, such periods are not uncommon during the solar cycle minimums of the past.

On September 11 a sunspot developed that ended a period of 52 continuous days with no spots. This is the fourth longest spot-free period on record. Both May and June 1913 were spotless, in a continuous spotless run of 92 days from April 8 to July 8. Cycle 19 was the biggest solar cycle on record, and it is interesting to note that it was preceded by long periods without spots. There was a 26-day spotless run from February 15 to March 4, 1953, followed by 27 days from January 12 through February 7, 1954, and 30 days beginning on June 3, 1954 and running through July 2.

Then, on September 22, 2008, SOHO (the Solar & Heliospheric Observatory) observed an active region with the first new-cycle sunspot since May 10, 2008 (figure 1). It had both the magnetic orientation and the high-latitude position of a sunspot belonging to solar Cycle 24.

Recent sunspots belong to either the dying Cycle 23 or to the new Cycle 24. How do we know which cycle a sunspot belongs to? Sunspots are classified based on the magnetic polarities occurring in the complex structures within the sunspot group. When one cycle merges into the next, the magnetic polarities reverse. The latest sunspots are more often occurring with the magnetic polarities consistent with the new solar Cycle 24.

Clearly, the new cycle has begun, even though it seems that the period of calm between Cycle 23 and 24 is unusually long. This sunspot, and the shorter time between recent sunspots, appears to indicate that our sun is waking up from a more normal-looking cycle minimum.

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Figure 1. After weeks of a spotless sun and very few sunspots this entire year, SOHO observed an active region (seen here on September 23, 2008) with the first new cycle sunspot since May 10, 2008. (Source: SOHO)

David Hathaway, NASA solar physicist, has reported that the quiet of 2008 is not the second coming of the Maunder Minimum. "We have already observed a few sunspots from the next solar cycle," he says. "This suggests the solar cycle is progressing normally."

During a solar cycle maximum, typically lasting several years, huge sunspots and intense solar flares are a daily occurrence. This in turn triggers spectacular auroras that at times are observable in Florida and New Zealand. VHFers enjoy such periods of intense activity because of the related modes of propagation—bouncing VHF signals off the *E*-layer during aurora or establishing DX contacts by way of a highly energized *F*-layer. I recall driving in my vehicle with a basic 6-meter mobile whip hooked up to an ICOM IC-706MIIG and having a reasonably long conversation with a famous bass player in a southern rock band who was traveling somewhere in the southeastern United States. While the solar maximum of Cycle 23 was not as intense as Cycle 22, there were some memorable moments in the years around 2000–2002.

During solar cycle minimums quite the opposite occurs. Solar flares are almost nonexistent, while whole weeks or even months go by without a single tiny sunspot anywhere on the

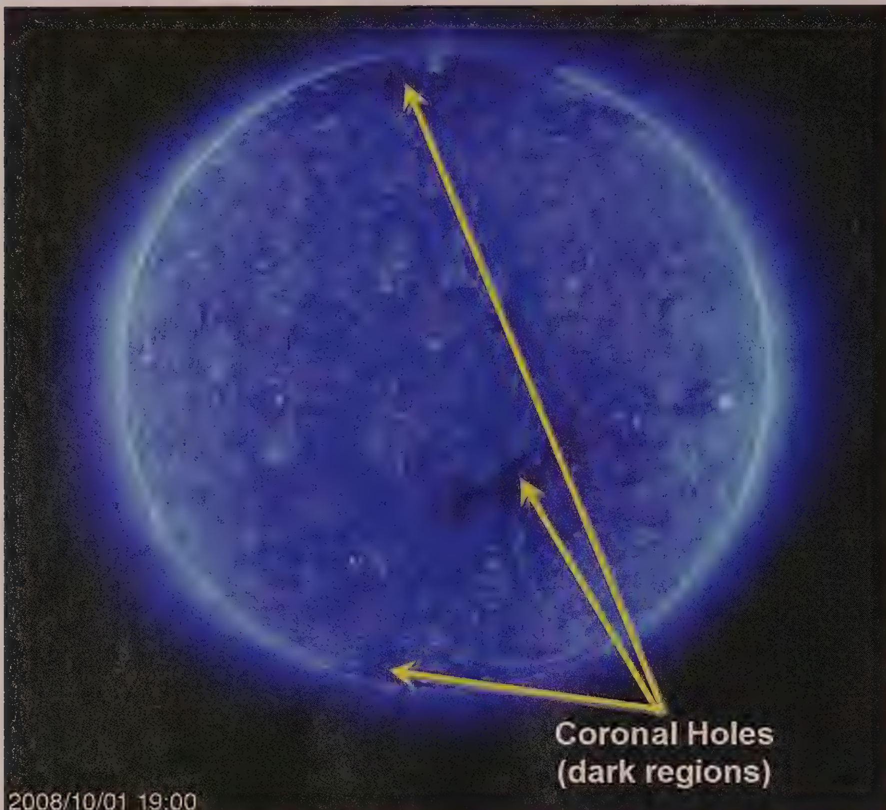

Figure 2. This EIT (Extreme untraviolet Imaging Telescope) image taken at a wavelength of 171 Angstroms reveals a "hole" in the solar atmosphere (corona). Such coronal holes are a source of solar plasma that escapes away from the sun, riding the solar wind. When clouds of solar plasma impact the earth's atmosphere during elevated solar wind storms, aurora may be triggered, resulting in the VHF aurora mode of radio signal propagation. During this period of sunspot cycle activity minimum, such recurring holes provide some life for the VHF weak-signal operator. (Source: SOHO)

sun. While there is continual coronal-hole activity (figure 2), which may trigger some aurora, the intensity and frequency of significant events that birth great VHF moments are rare at this point between solar cycles.

With the sun being so quiet lately, it seems that amateur radio operators are growing restless, asking the question, "Isn't this an unusually lengthy solar minimum?" With the media picking up on these mumblings, many are speculating that it is longer than usual and that perhaps something very significant is occurring.

"It does seem like it's taking a long time," allows Hathaway, "but I think we're just forgetting how long a solar minimum can last." The Maunder Minimum in the early 20th century is a case in point, where there were periods of quiet lasting almost twice as long as the current spell.

Hathaway has studied international sunspot counts stretching all the way back to 1749, and he offers these statistics: "The average period of a solar cycle is 131 months with a standard deviation of 14 months. Decaying solar cycle 23 (the one we are experiencing now) has so far lasted 142 months—well within the first standard deviation and thus not at all abnormal. The last available 13-month smoothed sunspot number was 5.70. This is bigger than 12 of the last 23 solar minimum values."

I concur with David that "the current minimum is not abnormally low or long." If the pattern from the record of the past 400 years holds, we can expect that solar activity will begin to show an increase in the next few months.

A Roaring Lion?

With the lull in ionospheric modes of VHF propagation, weak-signal VHF operators look forward to meteor showers, hoping that storm-level showers will provide exciting opportunities for bouncing their VHF signals off the plasma trails of burning-up meteors. Each year we hope that the November *Leonids* shower will yield a high rate of meteors per hour (the "ZHR," or zenith hourly rate). Will this year yield a major VHF meteor-scatter event?

Appearing to radiate out of the constellation of Leo from November 10 through November 23, the *Leonids* will peak on the night of November 17 and the early morning of November 18. This shower is known to create intense meteor bursts. Since the source of the *Leonids*, the Tempel-Tuttle comet, passed closest to the sun in February 1998, the years following were expected to produce very strong displays. The greatest display since 1998 was the peak of 3700 per hour in 1999. Every year since has been significantly less spectacular. This year the forecast is dismal: expect a ZHR of only 10 or so (there is one forecast, however, calling for a 130 ZHR). Try your VHF luck, because the unexpected may occur. If you are not on the air trying, you will never know.

The best time to work meteor scatter off the *Leonids* is around 11:30 PM local time in the Northern Hemisphere. The shower should increase in rate the closer you get to midnight, and then move toward pre-dawn.

December and January Prospects

After November, the annual *Geminids* meteor shower from December 7 to December 17 will peak on December 13. This is one of the better showers, since as many as 120 visual meteors per hour may occur. It is also one of the better showers for operators trying meteor-scatter propagation from positions in North America. The *Geminids* is a great shower for those trying the meteor-scatter mode of propagation, since one doesn't have to wait until after midnight to catch this shower. The radiant rises early, but the best operating time will be after midnight local time. This shower also boasts a broad maximum, lasting nearly one whole day, so no matter where you live, you stand a decent chance of working some VHF/UHF signals off a meteor trail.

Finally, check out the *Quadrantids* from January 1 through January 5, 2009. This meteor shower is above average, with peaks expected this season of around 120 meteors per hour. The best day should be the morning of January 4, just after midnight, and working through predawn.

Check out <http://www.imo.net/calendar/> for a complete calendar of meteor showers.

Working Meteor Scatter

Meteors are particles (debris from a passing comet) ranging in size from a speck of dust to a small pebble, and some move slowly while some move fast. When you view a meteor, you typically see a streak that persists for a little while after the meteor vanishes. This streak is called the *train* and is basically a trail of glowing plasma left in the wake of the meteor. They enter Earth's atmosphere traveling at speeds of over 158,000 miles per hour. Besides being fast, the *Leonids* usually contain a large number of very bright meteors. The trains of these bright meteors can last from several seconds to several minutes. It is typical for these trains to be created in the *E*-layer of the ionosphere.

Meteor-scatter propagation is a mode in which radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E*-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains.

Lower VHF frequencies are more stable and last longer off these ionized trails. A 6-meter contact may last from a second to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. Conversely, a meteor's ionized train that supports a 60-second refraction on 6 meters might only support 1-second refraction of a 2-meter signal. Special high-speed digital-modulation modes are used on these higher frequencies to take advantage of the limited available time, like high-speed CW in the neighborhood of hundreds of words per minute.

A great introduction by Shelby Ennis, W8WN, on working high-speed meteor-scatter mode is found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. Palle Preben-hansen, OZ1RH, wrote "Working DX on a Dead 50 MHz Band Using Meteor Scatter," a great working guide at <http://www.uksmg.org/deadband.htm>. Ted Goldthorpe, W4VHF, has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm>.

Autumn Outlook

Autumn (November through January) is a relatively quiet season, with very little if any Transequatorial Propagation (TEP). TEP, which tends to occur most often during spring and fall, requires high solar activity that energizes the ionosphere enough to cause the *F*-layer over the equatorial region to support VHF propagation. The normal TEP signal path is between locations on each side of the equator. However, without the level of solar activity needed to keep the *F*-layer energized enough for VHF propagation, these paths don't materialize. The fall season of TEP usually tapers off by mid-November, but this year TEP will be rare, if it occurs at all.

Tropospheric-ducting propagation during this season is fairly non-existent, as the weather systems that spawn the inversions needed to create the duct are rare. On the other hand, using tropospheric-scatter-mode propagation is possible, but one needs to have very high-power, high-gain antenna systems. Having dual receivers in a voting configuration would also help. The idea is to use brute force to scatter RF off water droplets and other airborne particles, and capture some of that signal at the far end with dual-diversity, high-gain receivers, not everyone's cup of tea.

Aurora-mode propagation is seasonally unlikely. Even if there were periods when the solar wind speed is elevated and is magnetically oriented in a way to impact the geomagnetic field, this is the season in which we statistically see very few aurora events.

The Solar Cycle Pulse

The observed sunspot numbers from June through August 2008 are 3.1, 0.5, and 0.5. The smoothed sunspot counts for December 2007 through February 2008 are 5.0, 4.2, and 3.6. The monthly 10.7-cm (preliminary) numbers from June through August 2008 are 65.9, 65.8, and 66.4. The smoothed 10.7-cm radio flux numbers for December 2007 through February 2008 are 70.5, 70.0, and 69.6.

The smoothed planetary *A*-index (*Ap*) from December 2007 through February 2008 is 7.8, 7.7, and 7.6. The monthly readings from June through August 2008 are 7, 6, and 5.

The monthly sunspot numbers forecast for November 2008 through January 2009 are 11, 14, and 16, while the monthly 10.7 cm is predicted to be 68, 70, and 71 for the same period. Give or take about two or three points for all predictions.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review).

Feedback, Comments, Observations Solicited!

I look forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information can be found at my propagation center at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing. 73 de Tomas, NW7US

Moondata Update 2009 and Related Comments

One of the most important factors in EME communications is knowing when it is best to communicate via moonbounce. W5LUU presents a summary and table of the best and worst conditions for EME in 2009.

By Derwin King,* W5LUU

The Earth-Moon distance and the cosmic (sky noise) temperatures in the direction of the moon are predictable, cyclical variables that set the basic quality of the Earth-Moon-Earth (EME) communications path for frequencies below 1.0 GHz. Best conditions occur when: (1) the Moon is at the absolute minimum perigee distance from the Earth and (2) the Sky Temperature behind the moon is the coldest along the moon path. The effect of distance is independent of frequency, but sky temperature decreases with frequency, up to ~1 GHz and then levels out. The EME signal-to-noise ratio, in dB, is usually degraded from the ideal by a factor (DGRD, see below) which varies over hourly, daily, weekly, monthly, and yearly time periods. As a guide for the basic weekend conditions for 2009, the W5LUU Weekend Moondata 2009 lists the DGRD, in dB, for 144 and 432 MHz, and other pertinent EME information for each Sunday at 0000 UT. Station, location, and factors such as ionospheric disturbances, local noise, antenna beamwidth, side lobes, polarization, etc., can increase the "apparent" DGRD.

EME conditions during 2009–10 will be the most favorable of the 9-year cycle. Now is the "best ever" time to take advantage of this mode. Ten weekends of 2009 are rated as Good to Excellent. Thirteen other days have 2-meter DGRD <1.0 dB. On May 1 it dips to 0.08 dB, and on Nov. 9 to 0.07 dB. However, during the traditional ARRL EME Contest period, sky noise at VHF is a problem for high north Moon declinations. Weekends around Oct. 11; Nov. 1, 8 (Good), and 30; and Dec. 6 (Excellent) are possibilities. For 1296 and up, the weekend around 9–13, high declination near perigee, should also be considered for the contest.

Definitions

DEC (deg): Moon declination in degrees north and south (–) of the equator. This is cyclical with an average period of 27.212221 days. The maximum declination during a monthly cycle, plus and minus, ranges from 18.15 up to 28.72 degrees with a period (maximum to minimum and back to maximum) of about 19 years. *The last maximum was on 9/15/2006.*

RA (hrs): Right Ascension, in hours, gives the east-west position of the Moon against the sky background. Average period of RA cycle is 27.321662 days, but it can vary by a day or so due to effects of the Sun on the Earth and Moon motion.

144 MHz Temp (K): The 144-MHz cosmic (sky) noise in direction of the Moon expressed as absolute temperature.

Range Factor (dBr): The additional EME path loss, in dB, due to Earth-Moon separation distance being greater than absolute minimum (348,030 km surface-to-surface). Varies from a low of 0 to 0 .7 dB at perigee up to 2.33 ±0.1 dB at apogee.

DGRD (dB): The degradation in EME signal to noise, in dB, due to: (1) the excess sky-noise temperature, in dB, at the stated position of the Moon compared to the lowest cold sky temperature and the system noise temperature (all at the frequency of interest); plus (2) the Earth-Moon range factor, dBr, for the listed time and date. The tabulated DGRD is referenced to the lowest possible sky-noise temperature along the Moon path, for a system noise temperature of 80°K at 144 and 60°K at 432, an antenna beamwidth of ~150, and to the absolute minimum Earth-Moon (surface-to-surface) distance.

The dBr affects DGRD equally at all frequencies, but sky noise decreases rapidly as frequency increases. During a monthly lunar cycle DGRD can vary by 13 dB on 144 and 8 dB on 432. DGRD varies less with small antennas than with large ones.

Moon Phase: Shows New Moon (NM) and Full Moon (FM) along with the number of days (d) or hours (h) before (–) or after (+) these events. At NM sun noise is a problem, while at FM the EME conditions (at night) are usually more stable.

Conditions: Summary of EME conditions as controlled by DGRD at 144 MHz and NM. Conditions may be worse due to ionospheric disturbance, local noise, and polarity, but not better than indicated. In general, 144 MHz DGRD <1.0 dB is considered Excellent, 1.0 to 1.5 is Very Good, 1.5 to 2.5 is Good, 2.5 to 4.0 is Moderate, 4.0 to 5.5 is Poor, and over 5.5 is Very Poor. Within a day of New Moon, high sun noise can make conditions Very Poor regardless of the DGRD.

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The information and accompanying table are printed here in CQ VHF *on a non-exclusive basis courtesy of Derwin King, W5LUU*

W5LUU Weekend Moondata for 2009
For Sundays at 0000 UTC

2009	DEC (deg)	RA (hrs)	144 MHz Temp. (°K)	Range Factor (dBr)	DGRD (dB) 144 MHz	DGRD (dB) 432 MHz	Moon Phase	Conditions
Jan 04	7.1	0.4	265	1.35	2.8	1.8		Moderate
11	23.4	7.5	320	0.08	2.2	0.7	FM – 3.5h	**Good**
18	–15.4	13.6	324	1.75	3.9	1.3		Moderate
25	–23.8	19.5	600	2.26	6.7	3.9	NM – 32h	Very Poor
Feb 01	11.4	1.9	282	1.32	3.0	1.9		Moderate
08	21.0	8.4	225	0.27	1.2	0.5	FM – 39h	**Very Good**
15	–18.2	14.1	352	1.70	4.2	2.4		Poor
22	–21.3	20.1	376	2.17	4.9	2.8	NM – 3d	Poor
Mar 01	15.4	1.6	302	1.17.	3.1	1.7		Moderate
08	18.6	8.7	187	0.54	0.9	0.6	FM – 3 d	**Excellent**
15	–20.9	14.6	388	1.70	4.5	2.5		Poor
22	–19.3	20.6	338	2.09	4.4	2.7	NM – 4d	Poor
29	18.9	2.3	341	0.91	3.3	1.5		Moderate
Apr 05	14.7	9.3	175	0.78	0.9	0.8		**Excellent**
12	–23.1	15.2	427	1.80	5.0	2.7	FM + 2d	Poor
19	–15.8	21.1	336	2.06	4.4	2.7		Poor
26	21.3	2.9	364	0.63	3.2	1.3	NM + 21h	Moderate but NM
May03	9.9	9.9	187	0.91	1.3	1.0		**Very Good**
10	–24.5	15.8	482	1.96	5.6	3.1	FM + 1d	Very Poor
17	–12.0	21.7	330	2.07	4.3	2.7		Poor
24	23.8	3.5	357	0.43	2.9	1.1	NM – 12h	Moderate but NM
31.	5.7	10.6	202	0.93	1.6	1.1		**Good**
Jun 07	–25.8	16.4	645	2.11	6.8	3.7	FM – 18h	Very Poor
14	–8.5	22.2	268	2.08	3.6	2.4		Moderate
21	24.8	4.1	374	0.36	3.0	1.0	NM + 44h	Moderate
28	0.9	11.2	217	0.86	1.7	1.1		**Good**
July 05	–26.9	17.1	944	2.21	8.4	4.1	FM – 2d	Very Poor
12	–4.7	22.8	244	2.07	3.3	2.4		Moderate
19	25.8	4.7	437	0.42	3.7	1.3	NM – 3d	Moderate
26	–3.3	11.1	245	0.77	2.0	1.1		**Good**
Aug 02	–26.5	17.8	2450	2.26	12.3	6.7		Very Poor
09	–0.9	23.3	244	1.98	3.2	2.3	FM + 3d	Moderate
16	25.5	5.4	510	0.55	4.4	1.7		Poor
23	–7.7	12.1	282	0.74	2.4	1.1	NM + 43h	**Good**
30	-25.8	18.4	2392	2.25	12.3	6.3		Very Poor
Sept 06	3.3	23.9	250	1.81	3.1	2.1	FM + 32h	Moderate
13	25.5	6.2	470	0.68	4.2	1.7		Poor
20	–10.2	12.7	314	0.83	2.9	1.3	NM + 30h	Moderate
27	–24.4	19.0	1028	2.22	8.8	6.0		Very Poor
Oct 04	7.1	0.4	265	1.60	3.1	1.4	FM – 6h	Moderate
11	23.4	7.0	371	0.72	3.4	1.4		Moderate
18	–13.0	13.2	318	1.03	3.1	1.5	NM – 5h	Moderate but NM
25	–22.7	19.5	607	2.22	6.7	3.6		Very Poor
Nov 01	10.6	0.9	280	1.40	3.1	1.8	FM – 43h	Moderate
08	21.0	7.7	267	0.63	2.1	1.0		**Good**
15	–16.8	13.8	358	1.29	3.6	1.9	NM – 44h	Moderate
22	–20.0	20.0	381	2.25	4.9	3.0		Poor
29	14.1	1.4	293	1.5	3.1	2.0	FM + 3d	Moderate
Dec 06	17.9	8.5	196	0.43	0.9	0.7		**Excellent**
13	–19.6	14.4	379	1.53	4.3	2.2	NM – 3d	Poor
20	–17.5	20.6	339	2.31	4.6	3.0		Poor
27	16.8	1.9	315	1.32	3.4	1.8	FM – 5d	Moderate

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Beckoning Beacons

How do you know if your rig is working? "Easy," you say. "Just call CQ and see who answers." True, but if the nearest DX is light years away, you can grow old, cold, and lonely awaiting that "QRZ" from Beyond. Such is the dilemma facing those radio amateurs pursuing interstellar DX, a practice otherwise known as SETI.

Maybe you're not trying to work DX at all, but are just an SWL. This, in truth, is more the case for the hundreds of amateur observers in the grass-roots, nonprofit SETI League who build sensitive microwave receiving stations, seeking radio evidence of technological civilizations out there among the stars. A receiving station is less costly than one that also transmits, for two reasons. The obvious reason is that a shortwave listener need not invest in a transmitter. However, beyond that truism, on a galactic scale (where transmitters need to radiate power levels that boggle the imagination), being a passive listener puts the burden of generating gigawatts right where it belongs —squarely on the shoulders of our (presumably older, wiser, and wealthier) cosmic companions. Earth is, after all, a young planet orbiting a young star. Other species, if they exist, are likely to be more ancient. If their planet has an expanding economy (a principle terrestrial economists call "inflation"), then they can afford better than we to radiate incredibly strong beacons, which just might reach our modest receivers as incredibly weak noise.

Now, receiving those feeble signals on Earth is no easy task. It requires searching through the quietest part of the spectrum, with the highest gain antennas, the most efficient feeds, the lowest noise receivers, and the cleverest digital signal processors we can muster. Thus, radio astronomers (whether professional or amateur) and those engaged in the scientific Search for Extra-Terrestrial Intelligence go to great pains for that extra tenth of a dB of sensitivity, as do weak-signal microwave DXers and moonbouncers. In fact, the SETI and EME communities have such a commonality of purpose that it makes good sense for them to share their technology, which is where our story begins.

*Executive Director Emeritus, The SETI League, Inc., <www.setileague.org>
e-mail: <n6tx@setileague.org>

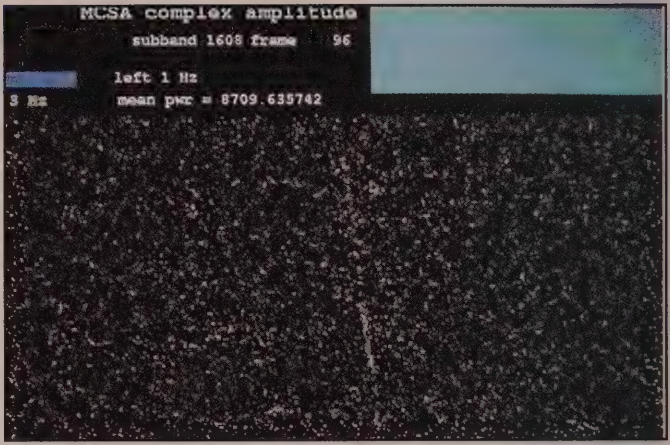

Figure 1. Drift-scan sweep of Quasar 3C273, about 3 dB out of the noise.

Natural Calibration Beacons

"You can't work 'em if you can't hear 'em," the saying goes. But how do you know if you can hear 'em, considering you don't even know for sure that they exist?

Forget ET for just a moment, and consider that the universe

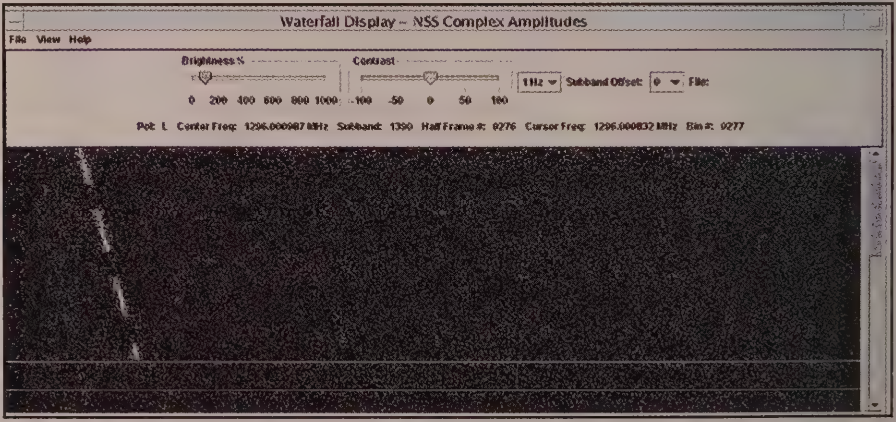

Figure 2. Mars Reconnaissance Orbiter beacon received by F5PL from Martian orbit.

is full of natural radio emissions. Stars, planets, moons, pulsars, quasars, supernova remnants, and even the chemicals that populate the black void between the stars all emit microwave radiation. Since its earliest days, radio astronomy has sought to study these emissions. Some are of known power, so you can calibrate your receiver's sensitivity on them. My favorite quasar, for example, 3C273, is known to emit +46 Janskys (a linear measure of flux density) on Earth at a frequency of 1420 MHz. Therefore, when I receive it 3 dB out of the background noise (see figure 1), I know the sensitivity of my receive station is half that level, or +23 Janskys. (This is, incidentally, a level of sensitivity typical of amateur radio telescopes and 23-cm moonbounce stations.) If I monitor 3C273 after tweaking my station and the received signal strength increases, I know my receiver is working better. If signal strength goes down, I know I should have left well enough alone.

Artificial Calibration Beacons

Since the beginning of the space age a half century ago, humans have been lobbing debris into space. Most of our space probes carry radio transmitters to send scientific (or perhaps less noble) data back to Earth. Might the signals emanating from our own spacecraft serve as calibration signals for terrestrial radio telescopes?

Indeed, they might, do, and have. Figure 2 shows a popular beacon signal from the Mars Reconnaissance Orbiter received in France (which, last time I checked, was on planet Earth) by amateur radio astronomer Bertrand Pinel, F5PL, as the spacecraft entered orbit around the Red Planet in March 2006. Since we know the beacon's power, we can use this signal to verify and quantify our station's performance. (Of course, the distance between Earth and Mars is always changing, so we need to do a little math to calculate the effects of varying path length and corresponding variations in isotropic free-space path loss.) Since we now have spacecraft orbiting or landing on many of our neighboring planets, as well as in orbit around the Sun, and orbiting the semi-stable Lagrangian points of the Earth-Sun and Earth-Moon two-body systems, we can enjoy calibration signals from a plethora of sources in space, all of Earthly origin.

SETI Calibration Considerations

Given the wealth of available natural and artificial calibration sources in space, which would prove most useful for the SETI enterprise? Consider that one challenge facing SETIzens is distinguishing between natural and artificial radio emissions. The latter tend to be extremely broad in spectrum, typically spanning MHz to GHz. Signals of technological origin tend to concentrate their energy in discrete carriers and sidebands. Thus, even in the case of purportedly wideband artificial emissions such as spread spectrum, detection against a backdrop of broadband natural radiation is facilitated by their narrowband spectral components. It follows that while wideband astrophysical sources serve us well as calibrators for continuum radio telescopes, those instruments optimized for SETI detection should be tested against artificial signals that closely replicate the narrow-band intelligent emissions that they seek.

For about three decades a popular SETI calibration source was the 20-watt S-band beacon aboard the Pioneer 10 space probe, the first human artifact to travel beyond the edge of our solar system. By the beginning of the 21st century, this robust calibrator had traveled beyond the range of even our most sensitive radio telescopes, forcing the SETI community to seek a calibration alternative.

In the next column, we will reveal how radio amateurs rallied to fill the gap.

73, Paul, N6TX

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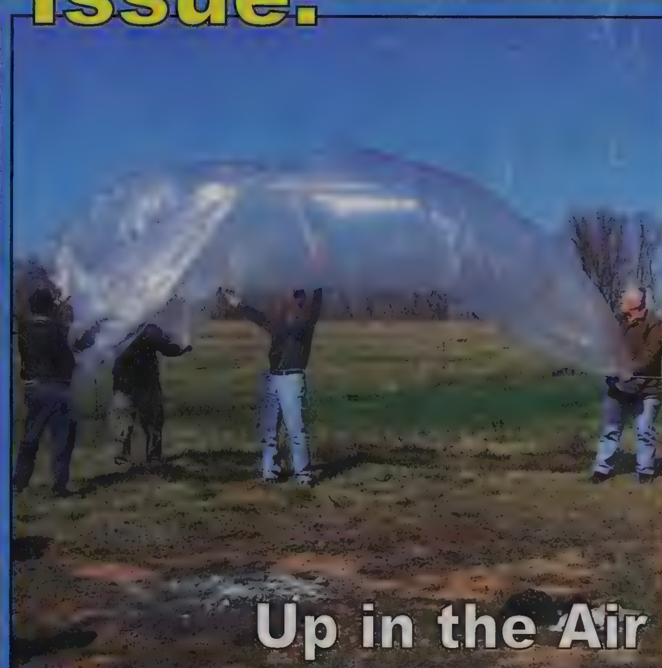

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CQ VHF Ham Radio Above 50 MHz

A Message from the Editor

Amateur Radio is Still an Adult Hobby

In her December 2007 *Reader's Digest* "Money Makers" column, Maria Bartiromo writes about a successful startup company directed at children and cellphone usage. Titling her story "The Will to Succeed," she features Daniel Neal, who got his idea to start Kajeet, a wireless service for kids, after observing just how savvy his preteen (nee-tween) daughter and other kids her age were in their use of cell phones. Partnering with Matt Baker and Ben Weintraub, two other dads, together they designed a kid-friendly cell phone that at the same time gives parents needed controls to keep their children safe from bullies (and other undesirable callers) as well as sets curfews so that their children aren't texting during school time.

To get to the final product, they spent two years in R&D, often in impromptu focus groups with their target market. For example, they tell of the story of encountering "tweens" at an airport on a field trip. They turned that "chance" meeting into an opportunity to listen to these kids and their chaperones and parents, who asked their respective questions about the cell phones that Neal and his partners were using. From that discussion and countless others, they developed a full-feature phone with voice mail, games, Internet access, and navigation service, along with text, pictures, and instant messaging, as well as the above-mentioned parental controls.

Bartiromo summarizes Neal's purpose in founding Kajeet as follows:

> Founding Kajeet, says Neal, was about doing the right thing for kids and parents. "I've always thought about technology as a tool that will not only help make our kids more connected but also enable them to be more competitive as the world becomes more interlinked." The challenge going forward, he says, is "to figure out the best way to bring educational content and application to this mobile platform in a way that excites kids about learning" *(page 65)*

It was when I was a tween that I first showed up at the doorstep of my neighbor's ham shack. It all started with my chance encounter with a college textbook on radio and electronics in the day room of the children's home where I lived for a couple of years after my mother's death. My father found that it was impossible for him to care for his children and work full time after my mother's passing. Nazareth House, a Catholic home for children, became the place for us to live until after my father remarried a couple of years later.

Reading that book fascinated me. In particular, I became enamored with wave propagation and antennas. After returning to our home, I spied a tall tower with antennas on it. I located its base, which was at this ham's shack in his back yard. I got the nerve to enter his property and pound on the door. When a man who was older than dirt in my childhood estimation answered the door, I announced that I wanted to learn more about his radio station.

Tentatively, he invited me in. After inquiring about my parentage and where I lived (a block and a half away), he proceeded to tell me about the hobby of amateur radio. After he turned on his Collins 75A4 receiver, he let me listen to it. However, he told me not to touch anything but to just listen.

Unfortunately, I did not listen to that last instruction. No sooner had he turned his back and I was twisting every knob I could get my hands on. Turning around toward me, he was livid. He told me to get out of his shack and not to come back until I could keep my hands to myself. I didn't go back for more than two years.

In the interim I got a new next-door neighbor who was a ham. Spying his call-sign license plate, I went over to meet him. At our initial meeting I announced that I wanted to become a ham. Fortunately, he took me under his wing and mentored me into the hobby by teaching me the theory and having me listen to military training Morse code records. When he deemed me ready, he had me order the Novice exam and administered the test to me.

It was about two months later when my ham license came in the mail. After my license arrived, with it in my hand I made my way back to the neighbor who had previously run me off. When I arrived at his ham shack door, sheepishly, I knocked. When he opened the door, I held up my license in front of my face and announced that I had learned my lesson and was now a ham. Then I apologized for my previous indiscretion and assured him that I would not touch a thing except under his instruction. After my speech, he invited me in and we became good buddies until his death.

My point in telling my story is that I first became interested in the hobby of amateur radio when I was a tween. With the critical help from an adult mentor, I got my license when I was barely a teenager. As a result of ongoing adult mentorship during my tween and teen years, my hobby has become a lifelong pastime that opened the door to my initial career as an electronics technician and now has me editing this magazine.

Even though I had adult mentors who made the hobby tween and teen friendly for my entry into it, thanks to the high interest in the hobby among my peers, I was able to hang out with a number of other fellow ham radio operators my age. Together we designed and built our stations from the rig to the antenna. We worked our DX and made our technology discoveries as youth. Graduating from high school, most of us went on to college and/or a career closely related to the hobby.

Now for the most part we no longer have this mentoring relationship with our youth. As a result, today's tween and teenage hams do not have a large number of contemporaries with whom they can hang out. As Bartiromo illustrates for the cell phone industry by way of her *RD* column, we need the adult involvement with youth in order to once again make our hobby tween and teen friendly. Otherwise, our hobby will remain adult oriented with little hope for future growth from the youth.

Therefore, in order to attract tween and teen newbies into our hobby, we must do for it as Daniel Neal has done for the cell phone—design tween- and teen-friendly access to it. This means that we need to listen to the tweens and teens (as well as their parents) via focus groups—both formal and impromptu—so that we can hear their concerns and meet them with ideas that will attract them at their level of technological development. In doing so, we will also "enable them to be more competitive" in their future career choices.

How do we proceed? In other words, to paraphrase Daniel Neal's words into a relevant question for us, "How can we figure out the best way to bring educational content and application to our hobby in a way that excites kids about learning?" I am open to your suggestions, which I will gladly publish in future issues of this, your magazine. Until the next issue…73 de Joe, N6CL

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Missioner II, a van turned space shuttle, made a five-day journey on the turnpike across Pennsylvania in April 1990. (Photos courtesy of the author)

Launching Dreams

The Long-Term Impact of SAREX and ARISS on Student Achievement

KB3NMS traces the nearly two-decade history of her students' involvement with SAREX and ARISS from their middle school days to their current careers.

By Patricia Palazzolo,* KB3NMS

NA1SS, this is WB4GCS on Primary. . .
NA1SS, this WB4GCS on Primary. . .
Nothing but static.
NA1SS, this is WB4GCS on Secondary. . .

Uh oh! With that exchange my heart nearly stopped! *Secondary* . . . and still no response? What was wrong? The huge room was filled with students, family members, teachers, and members of the media, and all eyes were glued to the wall-size tracking screen. We could see that the International Space Station was in the "footprint" over Pittsburgh, yet we heard nothing. Would the months of preparation leading up to this moment end in disappointment?

Once again came the calm voice of our amateur radio "wizard," Jim Sanford, WB4GCS:

NA1SS, this is WB4GCS on Primary. . . weak but readable . . .

Then we *all* heard it:

WB4GCS, this is the International Space Station, NA1SS. Your signal is getting stronger.

The collective breath released by all, and the brightness of the grins on every face, seemed powerful enough to blast us all into orbit without a shuttle! The excited students began their Q&A

*1415 Rostron Drive, Pittsburgh, PA 15241
(Printed courtesy of AMSAT and the author, this article was published in the 2007 AMSAT Symposium Proceedings.*)*

with Expedition 9 astronaut Mike Fincke, but in fact the opportunity for this exchange had its beginnings 15 years earlier with an entirely different group of eager middle schoolers.

Orbiting the Turnpike

Back in 1985, over 11,000 teachers completed lengthy applications in hopes of becoming NASA's first "Teacher-in-Space." After a long and grueling selection process, two teachers were chosen to represent each state and U.S. territory. I was thrilled to be selected as one of the two Pennsylvania representatives. I was assigned to the same training group as New Hampshire teacher Christa McAuliffe; after Christa's eventual selection as America's Teacher-in-Space, I was both pleased and honored that NASA appointed the remaining state finalists "Space Ambassadors" and assigned us the task of promoting aerospace education in our home states. In the months leading up to the *Challenger* launch number one, like the rest of the Teacher-in-Space finalists, I received requests to drive ever farther to conduct school assemblies, run teacher workshops, and give speeches. The public was definitely caught up in the dream. The nightmare came that January.

3—2—1—Liftoff! I watched *Challenger* rise, brighter than the sun, into that clear blue sky and heard the voice of the public affairs officer come over the loudspeakers at the viewing site: *Obviously a major malfunction . . . the vehicle has exploded.*

I returned to Pennsylvania to find a blur of phone calls, cameras in my face, and questions—questions as to possible damage to children's psyches, whether the Teacher-in-Space Project had been nothing more than a public-relations stunt, and whether we should be spending any money at all on the space program. What I did *not* return to find was any lack of the ability of space exploration to continue to inspire students and teachers.

And so it was on a warm spring day in 1989 that I received a phone call out of the blue from Mary Ellen Chuss-Mirro, a dynamic teacher in the small Sacred Heart School in the town of Bath on the opposite side of Pennsylvania. She had read that I was "NASA Space Ambassador" to the state and wondered if I had any ideas for "experiments" her middle school students could conduct to keep them busy so they would not "drive her husband crazy" while he drove them around the Bethlehem Raceway on a two-hour "mission" in the van that they had converted into a "space shuttle." I came up with several suggestions, and intrigued, called her back several weeks later to find out if the mission had been a success. Delighted with the outcome and bubbling with enthusiasm, she said her only concern was that she did not know how she would top it the following year.

"I do," I said. "Come on a mission across the entire state! My students will serve as mission control for your orbiter!"

The detailed planning would have made NASA proud—police escorts set up along the way, stops arranged at various venues on the route (including a special welcome by the governor in Harrisburg), experiments designed, a special "rover" built to be used to explore "Planet Pittsburgh" upon the crew's arrival, and computer tracking programs written by my students so they would be able to provide hourly reports to our entire student body about the location, speed, fuel consumption rate, and likely "landing" time of the "orbiter," known as *Missioner II.*

A real coup on our part, or so we thought, was having secured the use of a cell phones for the duration of the mission across the Commonwealth. At that time, very few "average people" had ever used, let alone owned, a cell phone. We were grateful to the company that donated the equipment and usage time of this "new-fangled" high-tech device that would help our mission control stay in touch with the van turned shuttle.

After a year of preparation, *Missioner II* blasted off on April 30, 1990 and began its five-day journey across Pennsylvania. For much of the mission, cell phone was useless. Fortunately, a couple of local hams, Seth Ward, KC3YE (SK), and his son Glenn, N3EKW, graciously volunteered to serve as our back-up communications system.

Not only was their ability to communicate with the van turned shuttle instrumental to the mission's success, it provided excitement and a genuine "mission control" feel to our site. The students loved seeing the radio equipment and hearing the details of the orbiter's progress across the state over the speakers. As the "shuttle" drew closer and closer to Pittsburgh, we began to hear other hams talking about it over the radio: *Did you just see that? Is that a space shuttle on the turnpike?*

On "final approach," I was a bit concerned about *Missioner II*'s clearance coming through one of Pittsburgh's famous tunnels. After hearing our ham radio volunteers discussing our tunnel situation, a ham listening in from a station in a rival school district could not contain his curiosity. He called to ask us just what we were trying to bring in through the tunnel. He had assumed it was some kind of big truck until he heard the words "wingspan" and "tail height." Our students got a good laugh when they heard him joke, "That's Upper St. Clair for you . . . always having to show off!"

The excellent work of our amateur radio volunteers saved the day. Our eighth grade mission control team was able to track the shuttle to a perfect landing at our front entrance. The entire school stood outside to cheer the arrival. It was indeed an amazing sight as it moved down the street with a motorcycle police escort firing 40,000 cubic feet of non-toxic smoke out of the main engines! (Yes, the firing of the main engines should not happen during a landing, but the middle schoolers who had been meticulously tracking an unseen object for almost a week wanted to see smoke and hear noise at the end.) *Missioner II* impressed even former astronaut Joe Allen, who was kind enough to join us for the event. (My "mission control" students had met him when they won a trip to the Hubble launch for their design of a shuttle experiment about soap-bubble kinetics in microgravity.) He grinned, patted its wing, and called hit a "really slick vehicle." The help we received from ham radio volunteers in tracking the van turned shuttle led to my next generation of students tracking the *real* thing just four years later.

From Mars to the Stars

During the same period I was working with the teacher in Bath on plans for *Missioner II*'s journey across the Commonwealth, I was contacted by visionary community members from a town much closer to Pittsburgh—Mars (yes, Mars!). Mars is about a 45-minute drive north of Pittsburgh, but at that time was rather rural in nature. The members of the Mars Area Foundation for Education Enrichment (MAFEE) contributed funds to provide special educational and cultural experiences to help their students realize that they were part of the world.

What special experience did the students seek? They wrote to then Soviet leader Mikhail Gorbachev to inquire, "Wouldn't you like the Russians to be the first to visit Mars, Pennsylvania, that is!" Never believing that they would actually receive a response, they were stunned by the arrival of a brief telex stating only that "Cosmonaut Hero Sergei Krikalev will visit the children of Mars in three weeks."

The students then wrote to NASA and said, "You're not going to let the Russians beat us to Mars, are you?" And so it was that Astronaut Mario Runco, Jr. joined Cosmonaut Sergei Krikalev for the first U.S.-Soviet mission to Mars (Pennsylvania!).

So it was, too, that I was called upon to serve as a true "Space Ambassador," especially when Sergei arrived alone and had no return ticket on Aeroflot, we had no translator available, and the nation he came from was still known as the USSR. Everyone was so grateful to have him as a guest for an entire week, but so nervous about making mistakes. We need not have been concerned. From making school visits to attending Pittsburgh Pirate games to serving as the grand marshal of a community parade, Sergei charmed us all.

Therefore, everyone took interest in his next mission on Mir. He was, after all, "our" cosmonaut. It was May of 1991, one year after our special shuttle-van-across-Pennsylvania event. My students who had, as eighth graders, served as mission control were now nearing the end of their first year of high school. They all had maintained their interest in science and technology, taking high-level courses and volunteering at the science center. By this time, encouraged by our amateur radio volunteers, I had earned my own ham license.

In May of 1991, the students were excited to know someone on Mir, but that excitement turned to worry when the Soviet Union disintegrated and stories of Sergei Krikalev being "stranded" in space made headlines. I was able to see him at the Association of Space Explorers Conference in Washington, DC in the summer of 1992, not long after he had finally returned to Earth as "the last Soviet citizen." The first thing he said to me was "Mars . . . the children?" He realized that the students he had met during his visit might indeed have been concerned about his welfare. He smiled when I gave him a chocolate space shuttle made by a Pittsburgh-area candy company to take back to his little girl. I assumed that our paths would never cross again.

It was the following summer when an amazing set of circumstances came together. I learned about the opportunity for students to speak with astronauts aboard the space shuttle through a program called SAREX. I now knew some wonderful people in the amateur radio community who might be willing to help, and I found out that the first Russian ever to fly on the American space shuttle was to be, of all people, Sergei Krikalev. Best of all, in spite of an incredibly tight schedule, Sergei's mission, STS-60, was to be a SAREX mission. There was just enough time to get an application in! There would be no guarantee that my proposal would be accepted, let alone assigned STS-60, but it was worth a try. For equipment and technical support, I turned to the North Hills and Butler Area Radio Clubs. I then approached the Mars Area School District with an offer I hoped they could not refuse: I would do all the work in writing the proposal, finding volunteers, and planning the event—if they would allow me to propose a joint effort between my school district and theirs. Half of the question askers had to come from my district, yet set everything up in Mars. (My own district never did quite understand why I based the event in Mars, rather than my own school. I explained to them that part of the SAREX application required explaining how one would attract the media. How could anyone resist headlines proclaiming that the shuttle had contacted "life on Mars," not to mention the fact that the first Russian to fly on the shuttle had already visited that town?)

The students who had tracked the shuttle van as eighth graders were now high school seniors. I turned to them to design a method of engaging the "new generation" of middle schoolers in SAREX. How could they develop a fair method of selecting the few students who would actually have an opportunity to ask a question? Letters would be sent home to every middle school child in the district. On the *outside* of an envelope, interested students would write the question they would most like to ask an astronaut in orbit. All identifying information, as well as a signed permission slip, would be sealed *inside* the envelope. My team of former students would go through all the questions and pick the best ones. Only then would the envelopes be opened and the identities of the question writers revealed.

I submitted our SAREX proposal . . . and waited.

When our proposal was accepted as one only five sites in the world to be scheduled for a SAREX contact with STS-60, there was joy in both school districts. With the help of some local hams, I began a series of assemblies to excite and inform all the students in both areas about amateur radio and space exploration. In the meantime, my team of 12th graders took their assignment of question selection very seriously. They wanted to be sure to come up with the most important, most interesting, most diverse combination of questions possible. It was their way of passing their torch to this next generation of students.

When the envelopes were opened, we were pleased to find that the "official question askers" included an equal mix of boys and girls. All were excited about the upcoming opportunity. Fourteen students—half from Upper St. Clair and half from Mars, all from grade levels 5 through 8—began to prepare for the big day that would come in February 1994.

The Contact Day

The morning of the contact day was electric. It seemed as if every newspaper and television reporter in western Pennsylvania had descended on Mars Middle School. The "SAREX kids," sporting sweatshirts with a huge STS-60 logo on the front, proudly posed before a large banner that said, "From Mars to the Stars." In between interviews, they practiced reading their questions so as to be prepared when it was their turn to hold the microphone. The school's main office had been set up like mission control and overflow crowds were able to watch the event from the cafeteria and gym on closed-circuit television. Back in Upper St. Clair, the school was open for the public to come in to watch the event unfold on a viewing screen set up in the auditorium.

As the time for contact approached, a call from NASA informed us to which crew member the students would be speaking. "Looks like it's going to be Sergei," said the voice. He could hear the cheer that erupted from the crowd. "I guess they're happy," he laughed.

We all watched the tracking program and saw the shuttle come into the footprint. Nothing. No response to our control operator's call. Tense silence prevailed as the shuttle moved away from the footprint. Finally, the voice from

NASA told us that "something had come up" with the deployment of the Wake Shield Facility and that essentially Sergei "didn't have his ears on." I was proud of the students' response. They smiled bravely and told the media it was still exciting just to hear the radio attempts. I knew they were disappointed, but part of their preparation had been to learn that SAREX was considered *secondary* to other shuttle experiments and operations, and that a school would only have one opportunity for contact no matter what interfered, including other things that might come up on the shuttle.

However, as we stood there, we heard the voice from NASA say, "Sergei would like to try again on the next pass, if you don't mind missing 90 more minutes of school." This time the cheer was even louder. The contact with Mars was being made via telebridge, so we actually were receiving the signal by bridge to a ham operator based in Australia and could thus wait for the shuttle's next pass.

The hour-and-a-half zipped by. Soon we heard our control operator calling the shuttle once again, and once again there was no response. Wait. . . was that something? Perhaps. Lots of static. . .no. . . the shuttle was out of range. The disappointment was palpable this time. (We later learned that the experts had a theory that the problem had something to do with a huge aurora.) Still, the students exhibited great dignity and maturity as they spoke of how it had been a "great learning experience."

At 11 o'clock that night my phone rang. It was my SAREX mentor wanting to know if we would like to give it an unprecedented third try in about 15 hours!

I frantically began calling 14 families at midnight, trying to make arrangements for everyone to return to Mars in the morning. I made calls to the media, the volunteers, and to our dear control operator, who lived almost two hours away. Everyone was willing to return.

In the morning we woke up to an ice storm! The Mars school district was closed, and my own had a two-hour delay. I kept in mind the poster I had hanging in my classroom: "You never fail unless you stop trying." There was no huge audience this time, but the amazing principal in Mars was able to get the Mars SAREX students in via police escort. Our wonderful control operator took a day off from work and braved the two-hour icy drive to set up the radio, and even a limited number of media returned. Unfortunately, there was no way to get my own SAREX students safely to Mars. The roads were just too bad. Then I had an idea.

I called the Johnson Space Center and asked if my kids could be patched in via speaker phone. At first they did not like the plan, believing it would be too difficult to have first a student from Mars ask a question, followed by one from Upper St. Clair. The delay would be too great and it would be too confusing. I asked them to just please let us try.

After testing the acoustics from various points in the classroom, Houston said the sound was the best when the speakerphone was placed on a chair near my desk.

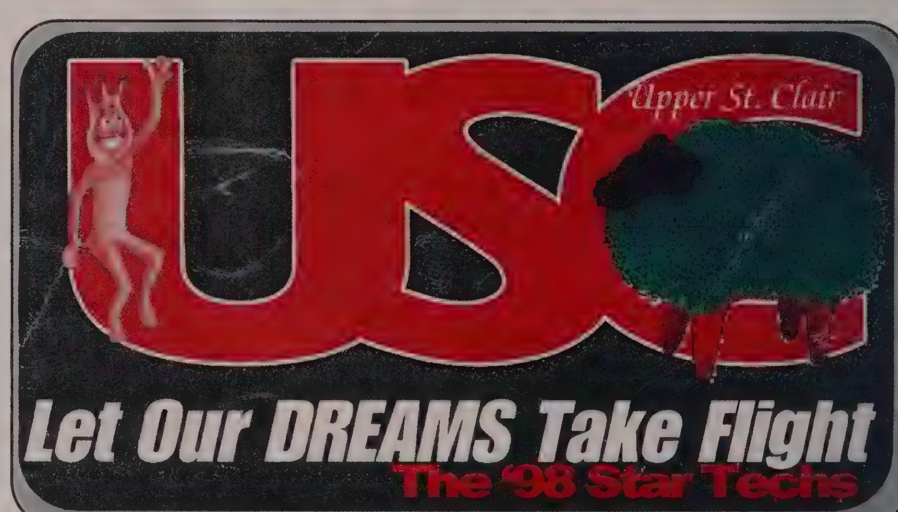
As the shuttle approached the footprint (which we could not see because the equipment was in Mars), my students, on their knees, gathered around the chair, waiting for their turns to scream their questions into the speakerphone. Their parents formed a ring around them. There was no media. We waited tensely. Then we heard the response for which we had been hoping: *This is U5MIR.*

It was Sergei! This was followed by the first question, posed by one of the "Martians." My student shouted her question into the phone as soon as Sergei had completed his answer to the prior question. The back-and-forth system was working well until my school began dismissing buses early due to the increasingly bad weather. *Bus 43 . . . Bus 71. . .* came over the PA system. The people in Houston informed us that they were hearing our bus announcements and threatened to cut us off. At that, some parents grabbed mousepads to tape over the speakers in the room while others raced to the main office to ask the principal to cut the announcements. The student questions continued successfully. At one point, a woman took Sergei's place in answering. It was difficult for him to make out children's voices, in English, over a less-than-ideal sound system.

Having the opportunity to speak with both Cosmonaut Sergei Krikalev and Astronaut Jan Davis on the first Russian-American shuttle flight was indeed very memorable! It was also a very special example of adults modeling persistence and teamwork for students. From the ham volunteers to the school administrators to the astronauts themselves, it was obvious that the willingness to be flexible and work hard could make important dreams come true!

The Next Generation:
John Glenn, Sea Monkeys, and Ch-ch-chia!

My special group of seniors felt good about having played a role in exposing my new generation of students to the wonders of science and technology. They headed off to college: Francesca to Georgetown with hopes of medical school, Noah to Notre Dame with plans for medical research, Kevin to USC for computer engineering, Amy to Cornell to study planetary science and earth systems, Joe off to Villanova for chemistry, Mike on to Michigan as a physics major, and others off to similar pursuits. As they departed, they kidded me. They had tracked a shuttle mock-up on the turnpike. My next group of students had communicated with the genuine orbiter. What



The logo of the next generation of students: "Let Our DREAMS Take Flight." DREAMS stands for Doing Real Experiments Adds Meaning to Science.

was to follow? Would my next students get to go into orbit themselves?

Not exactly, but thanks to the continued efforts of this "first generation" of students, my new group did get to send a little piece of Upper St. Clair into orbit. Over my many years of teaching, I have witnessed the imagination, learning, and accomplishments of my former students ripple out to touch others in wider and wider circles, like the rings of water from the proverbial pebble tossed in a pond. Amy continued to follow her passion for space science through college. At one point, while attending one of the very selective summer NASA academies, she became friends with a grad student who had designed a ratchetless wrench that was going to be flown as a shuttle experiment. He had just a tiny bit of space remaining in his container and was musing about "some teacher" perhaps being able to have kids think of what to do with that space. Amy immediately responded, "I know just the teacher! I know just the kids!"

I received a phone call from Amy the very last week of school and was told that we had one week to try to design an experiment for that small bit of "leftover space," and that experiment had to meet all of NASA's requirements or we would lose the opportunity. In short, my students had to operate as real scientists.

At first, my middle school students had difficulty understanding that the experiment would be loaded into the shuttle during the summer and sit there for at least two months. Thus, no, they could not send up anything that was alive and our allotted space was just a few test tubes. They finally hit upon the idea of sending Sea Monkey (brine shrimp) eggs, since they would be able to "bring them to life" after their time in space. However, they also wanted to send some flora along with their fauna. Suddenly, one of the students started singing the "Chia Pet" jingle: *Ch-ch-chia. . .Ch-ch-chia!* Why not? One never seems to see them for sale except at holiday time, so they must store well. The experiment design began in earnest, with the students working through much of the summer to meet NASA's standards. The most memorable was the day they were actually able to load their experiment into the special container NASA had sent us, and to place the mission patch they had designed on that container. The patch depicted both a Sea-Monkey logo and Chia Pet sheep, as well as the students' own motto: *Let Our DREAMS Take Flight,* with "DREAMS" standing for "**D**oing **R**eal **E**xperiments **A**dds **M**eaning to **S**cience."

Throughout the design process, the students had only known that their experiment would fly on "a" mission. It turned out to be *the* mission of 1998: STS-95, 77-year-old John Glenn's return to space. That being the case, my little team received far more than their "15 minutes" of media attention. Nevertheless, the stars in their eyes were not so bright as to dim their excitement at viewing the launch and feeling humbled in realizing that something they had put together was indeed being carried into orbit.

As for Amy, now starting her Masters in Science, Technology, and Public Policy at George Washington University, it was another ripple in the pond. The students involved in this project began high school on fire and took advantage of every science and engineering opportunity throughout the next four years. When they were high school seniors, they finally had the opportunity to meet John Glenn and his wife Annie in person during the cou-

ples' visit to Pittsburgh. The Glenns generously spent half an hour with us privately. As I watched these students speak to Colonel Glenn, I realized that their resumes now included Governor's School for the Sciences, several national awards for science and engineering projects, important summer internships, Eagle Scouts, and even the collection and refurbishment of 30 discarded wheelchairs that were then sent to hospitals in Vietnam. They all had been awarded scholarships to top universities, with one even having already been accepted for a full ride to medical school, and they had not yet officially graduated from high school!

The Adventure Continues:
From SAREX to ARISS

Early in 2004, yet another opportunity presented itself. I received a voicemail message at school asking me to call NASA—something about being a "crew pick" for an ARISS contact. What did that mean?

As it turned out, Pittsburgh astronaut Mike Fincke was going to be the Science Officer for Expedition 9 on the International Space Station, and he had selected my school with which to make an ARISS contact! I was thrilled, yet confused. I had never met Mike Fincke and he had never attended Upper St. Clair Schools. How did I get to be his "crew pick"? Why wasn't he going to do an ARISS contact with his own school? Was this a prank?

I soon learned that it was a genuine opportunity! Col. Fincke had promised an Upper St. Clair grad working in life sciences/countermeasures at the Johnson Space Center that if he ever had the chance to go into space, he would make a school contact with the school of her choice. When his flight assignment came, he remained true to his promise, and of course she selected her alma mater for the contact. Although this particular young woman, Lesley Lee, had graduated before I began teaching in the district, she was aware of the kinds of special projects my students and the supportive community had been able to pull off over the years. This project would definitely require skill to be a success, because unlike the SAREX, which had been difficult enough to accomplish in Mars, this would *not* be a telebridge. This was to be a "direct." Add to that the Upper St. Clair landscape, where every building is built into a hillside, and my concerns over finding a way to set up an antenna to clear both buildings and trees grew serious. For that matter, where could I even find someone with the right antenna? Where could I find someone who could set up the correct equipment?

I turned to my local amateur radio club, WASH, the Wireless Association of South Hills, which in turn engaged the cooperation of WACOM, Washington Area Communications. Their energy, passion, commitment, and expertise were boundless even as the contact date kept slipping and everyone had to keep changing their vacation dates. They took over everything having to do with the setup, from stringing wire through the school roof, to splashy camera and sound setups, to T-shirts! All I had to do was deal with the students.

This time, instead of middle school, I wanted to involve a range of ages of children. The students selected to ask questions represented each grade level from fourth through twelfth. I named them the "ARISS Ambassadors," and informed them that part of their job would be to act as my liaisons to each of their respective classes. I would call upon them to keep their classmates updated on information related to space, science, and technology throughout their years in the Upper St. Clair School system. It would also be my hope that as they graduated and moved on to college and careers, they would continue the ripple-in-the-pond effect of contributing to others, including offering any learning opportunities possible to the next generation of students who would follow them.

. . .This is the International Space Station, NA1SS. Your signal is getting stronger. . .

Jim Sanford, WB4GCS, turned the microphone over to ninth-grader J. T. Gralka, who asked the first question, while Kevin Smith, N3HKQ, prepared the next student to quickly take his turn. I stood offstage to guide each student who had asked a question safely clear of the next child leaving the platform. They were starry-eyed from the experience, and I know that their minds were no longer connected to their body movements. I did not want to see a domino-style pileup of my ARISS Ambassadors! I, too, was dizzy with excitement and grateful that someone was recording Mike Fincke's answers. I vaguely realized that he was responding in ways that ranged from humorous to poetic, but I could not get my mind to register anything beyond "The kids are talking to an astronaut on the ISS! It's really happening!"

I became aware that the students had the same experience when reporters begin to ask them what they thought of the answers to their questions. I almost laughed when I saw the puzzled look in their eyes as they suddenly realized that they couldn't remember what Mike had just told them. It was fine. The details would return to our brains later. For then, it was enough just to bask in the glow of a successful ARISS contact and thank all those who made it possible, just as we did over a decade ago after our SAREX with STS-60. A random thought passed through my mind: After beginning with a contact date of "anywhere between May and September," and through numerous slips of the official date, once we had been given one, we had finally made successful contact on August 27. That day was Sergei Krikalev,U5MIR's birthday.

The Next Generation of Explorers

NASA's new mission has set goals that move beyond simply "inspiring" children to consider careers in science and technology: engagement, education, and employment. It is important for students to seek strong educational foundations in these fields as a means of retaining an interested, well-trained work force, as well as to engage the public in a vision that supports science, technology, and space exploration. Various reports of the monumental number of students, teachers, and the general public who have witnessed, heard, or read about SAREX and ARISS contacts have been issued over the years. I know that after a SAREX or ARISS contact, I have had to send the ARRL reports of "my numbers" in terms of live audience, those watching from satellite locations, teachers who may have been in-service, newspaper article readership, and even the number of those who may have viewed a news story about it on television. Those statistics reveal the tremendous outreach of SAREX/ARISS, and no one can watch the faces of those viewing students talking via amateur radio to an astronaut and doubt the inspiration factor, even those who are simply audience members.

However, it is vital that we consider the long-term impact of that inspiration. The students who were actually selected to

Amy (Snyder) kaminski participating in a NASA Academy as a college student. Today Amy is Space Programs Examiner for the White House.

ask a question, or in some cases to help set up the equipment, are significantly smaller in number than those reported as "audience members." Yet if the inspiration of that hands-on experience at a crucial age can inspire these children to pursue education and enter careers at the passionate and high quality level that I have witnessed among my own former students, then the positive impact of SAREX and ARISS goes far beyond any numbers found in reports. All of my students who participated in SAREX/ ARISS—or were the original "mission control" team tracking *Missioner II* across Pennsylvania—have gone on to phenomenal accomplishments and careers that contribute much to society. Almost all have opted for careers in science, technology, or science-related fields (such as MBAs working for technology firms or patent lawyers). There are many medical doctors and information technology specialists. One is now an amazing calculus teacher whose classroom is next door to mine! Therefore, I will highlight just a few examples from each of my "generations of explorers." They now range in age from 12-year-olds to professionals in their early 30s.

The "First Generation": Missioner II Mission Control

Noah Gray went on to Notre Dame and then finished a PhD in neuroscience at the Mayo Clinic, where he investigated vesicle trafficking and endocytosis before joining the Cold Spring Harbor Laboratory on Long Island, New York. He later conducted research at the Janelia Farm Research Campus (Howard Hughes Medical Institute), which is the world-class center known for bringing together the best scientists from many disciplines to collaborate on small teams to try to solve some of the world's most challenging problems. He currently is assistant editor of *Nature Neuroscience*, the top journal in its field

Joseph Pickel completed a BS in chemistry at Villanova, followed by a PhD in polymer chemistry at the University of Akron (Ohio). He currently is a polymer chemist at the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory in Tennessee. The center is the first of five nanoscience research centers funded by the US Department of Energy. Joe's research group is dedicated to "making polymers behave the way we want them to" so that they can be useful in fuel cells, making lighter and stronger cars, biomaterials, and more. In Joe's words, "I'm loving it!" Joe has also had to become an expert glassblower, since polymer chemists often have to make the supplies they need for their experiments

Michael Weinberger finished his BS is working for Texas A&M University on the CDF experiment at Fermilab in Chicago, and the CMS experiment located outside Geneva, Switzerland. In his most recent note to me Mike said, "I am in the middle of working right now and am actually underground in France working on electronics for the CMS particle detector as I type this."

Amy (Snyder) Kaminski studied planetary science and Earth systems at Cornell, where she also added a minor in science journalism after having attended a shuttle launch with me with a press pass. She became editor of Cornell's "Science and Technology Journal." Amy received a Masters in Science, Technology, and Public Policy at George Washington University, specializing in Space Policy, while also authoring a book with "space

"Second generation" students eager to see their experimental launch with John Glenn in 1998. Megen Vo is standing on the left, with teacher Pat Palazzolo on the right. Sitting, left to right, are students Matt Muffly, Karl Zelik, Dan Zelik, and Dan Doan.

law expert" John Logsdon. She has published many articles on astronomy, as well as articles on space tourism, and is often a featured presenter at the very NASA Academies she attended as an undergraduate Amy did an internship with the Rand Corporation. She then worked with the FAA Commercial Space Division as the "Office Lead" on both Space Tourism and Space Debris; on the Board of Women in Aerospace; and is featured in a book about 100 powerful woman in the space industry aimed at middle school girls. She currently is Space Programs Examiner for the Office of Management and Budget.

The "Second Generation": SAREX and Sea Monkeys

Megen Vo was featured in the Nickelodeon program *Figure It Out!* The panel had to try to figure out what was so special about the "pets" Megen had brought to the studio in Orlando (flying them in all the way from Pittsburgh). Of course, they were our actual sea monkeys that had been to space with John Glenn back when they were just eggs. Megen currently is in medical school at Case-Western University.

Matthew Muffly was accepted into the Pennsylvania Governor's School for Health Care during high school (a highly selective summer program). He was been a research assistant for a hand surgeon throughout college and has had an article published in the *Journal of Hand Surgery*, He is about to start medical school

Daniel Doan became concerned about problems faced by hospitals in Vietnam, which do not have enough wheelchairs for their patients. For his Eagle Scout project, he rounded up broken and discarded wheelchairs from area hospitals, took classes in how to repair them, and single-handedly refurbished 30 wheelchairs in his family's garage. When faced with the problem of delivering them to Vietnamese hospitals, he was able to get the World Vision organization to send them. He was granted a full scholarship to undergraduate studies and medical school by the the University of Pittsburgh while still a high school senior. He currently is in medical school

Karl Zelik completed a BS in biomedical engineering at Washington University in St. Louis. He spent undergrad summers working with mechanical hearts in Pittsburgh. This past year he worked developing bionic prosthetics at St. Jude Hospital. He currently is working on his Masters in mechanical engineering at Michigan State.

Daniel Zelik received a full scholarship from Iowa to work on his Bachelors in industrial engineering, with a minor in psychology. As his co-op program, he spent months at a time working with NASA at the Johnson Space Center. He currently is working on his PhD in human factors engineering at Ohio State.

The "Third Generation": The ARISS Ambassadors

Benjamin Burns had perfect SAT scores, but was equally strong regarding civic responsibility. He was on the First Place Design, Engineering, & Fabrication team in high school and nationally ranked as a math student. Currently he is an undergraduate at Harvard studying engineering and physics and also working in the Harvard Observatory.

Matthew Boyas was on the Future Problem Solving Team that qualified to represent Pennsylvania at the Inter-

The "third generation," Sarah Perrone and Matt Boyas with their award-winning Exploravision project.

national Future Problem Solving Finals, where the team finished fourth in the world. He has three honorable mentions from Toshiba for papers submitted for the Exploravision Contest. In January one of those papers is featured in a textbook called *Nanotechnology 101* (Greenwood Publishing group). He has served well as an ARISS Ambassador, including assisting me in running science events for my middle school students. He currently is a high school junior.

Conclusion

After more than two decades and well over 500 successful school contacts, have SAREX and ARISS served to "inspire the next generation of explorers as only NASA can?" Reports that count the number of people "exposed" through these events to science and technology—and, more specifically, to both amateur radio and to NASA—reveal sky-high numbers. However, in this article, a longitudinal case study of one teacher's lengthy involvement with these activities over the course of her career, I have sought to provide specific follow-ups of the students most deeply involved at the time. SAREX and ARISS inspire engagement, education, and employment through:

- Providing "hands-on" learning
- Making real-world connections among disciplines
- Requiring problem-solving while under the pressure of deadlines
- Demanding excellent communication skills
- Illustrating the importance of technology and the joy that sharing one's skills can give to others
- Allowing adults to model the power of passion, partnership, and persistence

My former students continue to work in exciting high-tech fields and continue their willingness to help my current generation of students. Recently, I e-mailed a number of my prior students requesting their help with an educational proposal for a shuttle downlink. The response was immediate and overwhelmingly positive. Mike Weinberger e-mailed me from underground in France, writing: "I hope I am not too late to help with this project. I would love to help out the current students." From Tennessee, Joe Pickel wrote: "I would *love* to take part in this project. . . . please tell me what you need and I will help out."

Last spring, a team of my high school students made the national finals of an academic competition, for which they traveled to Washington, DC. The highlight of the trip was a tour of the White House that Amy Kaminski was able to arrange for them. Even more impressive than the tour in their minds, however, was the fact that it was the "legendary Amy" herself who was accompanying them as they walked through the White House. Amy's willingness to "scramble" on last-minute notice to allow my students to participate in the tour, as well as the willingness of Mike and Joe to fit us into their hectic schedules, have roots, I am certain, that go back to the amateur radio volunteers and others who gave of their time and expertise when these students were so young.

I am but one teacher who is very proud and humbled by the accomplishments of her SAREX and ARISS students over the years. I am especially proud of the lives they have touched and their willingness to "give back." Is there a long-term impact of SAREX and ARISS on student achievement? I am but one teacher. There were well over 200 SAREX school contacts, and there have already been over 300 ARISS school contacts. Just do the math.

2007 AMSAT Symposium
A Report on the Revolution

Since the 2006 AMSAT Symposium, AMSAT's leadership has been working on developing a well-defined mission and vision for the future of amateur radio in space. Here K9JKM reports on the results of the leadership's efforts, which led to several exciting announcements at this year's symposium.

By JoAnne Maenpaa,* K9JKM

"The Conference that would Revolutionize the Amateur Radio Satellite Service." Such was the theme that AMSAT President Dr. Rick Hambly, W2GPS, presented in his welcoming letter, which was published in the *Proceedings* of the 2007 AMSAT Symposium. Indeed, even the venue of the symposium carried the theme of change. Held over the weekend of October 26–28, 2007 at the Pittsburgh Airport Marriott Hotel, which is nestled in the hills of western Pennsylvania, its participants were treated to the vivid change of colors of the leaves of autumn.

As the changing colors of the autumn leaves signaled both a natural end and beginning, so did President Hambly signal both an end and a beginning for AMSAT with two revolutionary announcements: a proposed new geosynchronous satellite and the AMSAT Institute. Other important plans for 2008 and beyond were also announced. They include: the placing on line of AMSAT's Satellite Integration Laboratory in Pocomoke City, Maryland; the expected completion of AMSAT-DL's Phase 3 Express High Earth Orbit satellite; and the beginning of construction and testing of AMSAT's Eagle, its latest High Earth Orbit satellite.

From left to right: Bob McGwier, N4HY, Lee McLamb, KU4OS, and Rick Hambly, W2GPS, discuss technical aspects of the planned geosynchronous satellite. (N6CL photo)

Proposed Geosynchronous Satellite

The most revolutionary and exciting news coming out of the symposium was President Hambly's announcement of a proposed geosynchronous satellite. Hambly, along with Bob McGwier, N4HY, AMSAT's Vice-President of Engineering, made public the results of their recent behind-the-scenes work that will change the playing field of amateur radio satellite communications.

As a result of conversations by AMSAT's leadership with Intelsat (the world's largest commercial satellite communications services provider) concerning their communications satellites carrying our amateur radio satellites into geosynchronous orbit, an agreement between the two entities has been proposed. McGwier indicated that this potential agreement came about as a result of changes in Department of Defense policies which will require DoD-subsidized launches to allow secondary payloads to fill in excess launch capacity of the primary mission.

As if to add to what Hambly and McGwier stated in their presentation, during his subsequent talk "Where's the Launch?" Lee McLamb, KU4OS, explained factors such as the increased size and efficiency of launch vehicles now resulting in excess lift capacity. No longer is it the case that adding weight to the payload means removing fuel (weight) from the booster. Lee added that current missions have 1000–1500 pounds of excess capability of which AMSAT can easily take advantage.

Hambly pointed out that with this new commercial launch reality, AMSAT may actually be able to launch earlier to a high orbit if its satellite fits into the Intelsat ride-sharing model. He added, "We need to be ready for this event."

This new project has been designated Phase IV Lite because of the planned incorporation of much of the Phase 3, P3E, and Eagle satellites' technology in the proposed geosynchronous satellite.

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Richard Crow, N2SPI, is shown instructing middle and high school students on the construction of homebrew satellite antennas. (N6CL photo)

In discussing the engineering aspect of the proposed agreement, McGwier remarked that while the upside potential is great, many of the technical details still need to be worked out. "Even so," he stated, "there is enough in place at this time that AMSAT needs to begin planning engineering work and possible construction of a geosynchronous payload so we are ready if Intelsat says they have a ride for us."

With the incorporation of technology from satellites already under development, it will be natural for AMSAT to also proceed with the development of its planned easily accessible Earth station which will take advantage of the audio, digital messaging, and video services offered by the resulting advanced communications package (ACP). The details of the ACP appear below under the "AMSAT Eagle Update" heading.

The ACP earth station would be self-contained and would be sent with an amateur radio communications team or delivered to a disaster area in order to supply emergency communications. Such a team would be able to point a small dish at the spot in the sky where the geosynchronous satellite is "parked" and immediately begin providing disaster communication support without depending on HF propagation.

Another feature of the Phase IV Lite satellite would have a direct bearing on the ARISS (Amateur Radio aboard the International Space Station) program. For example, part of the payload could be used to provide a tracking and data-relay satellite system (TDRSS)-like relay of the ARISS communications via the Intelsat system of satellites. The advantage to the ARISS program is that a previously hopelessly short ARISS QSO could last for hours, thereby opening the possibility of student involvement with experiments onboard the ISS.

McGwier also pointed out the advantages of Intelsat geosynchronous platform. One advantage is that Intelsat's primary payload would perform the geosynchronous transfer orbit (GTO) boost phase as well as perform station upkeep and antenna pointing once it has arrived in its orbit. Furthermore, Intelsat can drop off sub-payloads into low earth orbit (LEO), GTO, or geostationary orbit (GEO) on the way to the primary mission. Additionally, the excess power built into the design of the satellite would be able to furnish the AMSAT Phase IV Lite payload with approximately 400 watts of DC power for upwards of 15 years, thereby eliminating the need for AMSAT to provide solar cells.

The advantage to AMSAT is that AMSAT does not have to design these features into its satellite. Summarizing his points, McGwier added, "The Intelsat team would be doing all the things nearly impossible for amateurs, thereby enabling AMSAT to do what we do best, that being building a communication system that changes amateur radio for the better!"

New Education Institute Planned

Education, from primary to secondary through higher education, has always been and continues to be one of AMSAT's major missions. It was no surprise then that President Hambly's second major announcement had to do with education. As part of his announcement, Hambly pointed out that AMSAT's cooperation agreement with the University of Maryland Eastern Shore has resulted in an additional educational opportunity.

The agreement already provides the laboratory facilities for AMSAT's new Spacecraft Integration Laboratory in Pocomoke City, Maryland. This laboratory is also a collaborative effort between AMSAT and the Hawk Institute for

The new AMSAT Laboratory in Pocomoke City, Maryland. (AMSAT photo)

This student displays the completed homebrew satellite antenna that he constructed during the N2SPI workshop. Several of the students successfully copied the SO-50 with their newly constructed antennas. (AMSAT photo)

Space Sciences (HISS), also located in Pocomoke, which is on the eastern shore of the Chesapeake Bay.

It was determined that a natural outgrowth of this arrangement could be a venue for training a team of educators in space subjects and satellites. These educators would then branch out and train more teachers to bring AMSAT and amateur radio into their classrooms. This synergistic brainstorming by the leadership of AMSAT, HISS, and the University of Maryland Eastern Shore resulted in forming the AMSAT Institute. The first session of the institute is expected to take place this summer. More information on the AMSAT Institute will be available on AMSAT's website (http://www.amsat. org) as it becomes available.

AMSAT Maryland Lab Update

During his presentation, Bob Davis, KF4KSS, AMSAT's Lab Manager and Assistant Vice-President of Engineering, discussed the progress of finishing the new 8,500-square-foot AMSAT Spacecraft Integration Lab in Pocomoke. As of this writing, the cleanroom is being completed. To date the office walls have been completed, and the laboratory, electrostatic workstations, soldering equipment, and machine shop all have been constructed. The facility will also include a satellite earth station expected to be completed this February. The laboratory will begin to be used with a university Cubesat project in accordance with AMSAT's agreement. Additionally, the Eagle satellite will be built and integrated at this facility.

AMSAT-DL Phase 3E Update

During his presentation, Hartmut Päsler, DL1YDD, Vice-President and Board Member of AMSAT-DL, discussed the current status of the P3E mission. Regarding P3E, Hartmut explained that with international cooperation from AMSAT-NA and AMSAT-UK, it is nearing completion for assembly and testing. With the closing of Research Centre Jülich's Central Electronics Laboratory (ZEL) by the end of 2007 or early 2008 as P3E is completed, it should be ready for launch. AMSAT-DL is currently looking into launch possibilities with Ariane and Soyuz-2. With the announcement of the potential cooperation with Intelsat, additional launch opportunities also may become available.

AMSAT Eagle Update

It was announced that the current baseline plans for Eagle's linear transponders are being expanded into dual-use for Phase 3 and Phase IV application. These features include:

- UHF uplink/VHF downlink linear transponder using Software Defined Transponder (SDX)
- L-band 1269-MHz uplink/S1-band 2400-MHz downlink linear transponder (also SDX)

The details of the Advanced Communication Package (ACP) planned to be used on Eagle and Phase IV are to include these capabilities:

- S2-band 3400–3410 MHz downlink and C-band 5650–5670 MHz uplink (10-MHz segment TBD)
- A phased array with up to 22.4 dBi gain is under study
- Uplink and downlink would be accessible to hams not already on satellites or facing antenna restrictions; a 60-cm dish would work for all users
- Simultaneous development of earth-station package accessible to the average ham
- Earth stations available for emergency communications (EMCOMM) teams and educational outreach (for more information, please see above)
- Probable capacity of 500 text rate, voice-grade channels, and video—scalable data rates depending on the class of the communication application

SuitSat-2 Update

Lou McFaddin, W5DID, described the ongoing design and construction of the communication and experimental payload for SuitSat-2, which hopefully will be deployed in 2008. The SuitSat-2 project will feature:

- Expanded educational outreach
- Linear software defined transponder
- CW ID
- Voice messages
- FM crossband repeater
- SSTV images of the Earth from four cameras
- Temperature sensors
- Room to accommodate four experimental packages
- CD-ROM containing student art and messages

ARISS Continues to Reach More Students

Commenting on ARISS during his presentation, Frank Bauer, KA3HDO, ARISS International Chairman, discussed the seven years of continuous operation of the ARISS program. Bauer summarized the success by citing the statistics of its success. With AMSAT as its key partner in the ARISS program, and the main suppliers of mentors, to date the ARISS program has made over 330 school contacts by 16 consecutive amateur radio licensed crews. It is estimated that the program reaches over 15,000 students per year. While it was announced that because of the workload in December (that now extends into early 2008 with the December 2007 cancellation of the launch of the shuttle *Atlantis*), ARISS contacts will become very scarce for the

Pat Sanford, KC4WTT, coordinated the hosting of the symposium. (N6CL photo)

near term. Eventually, when the workload is caught up, classroom contacts and amateur radio operations aboard the ISS are planned to continue and grow in 2008.

Onsite Youth Education Opportunity

Inspired by their conducting a 2005 ARISS QSO for Upper St. Clair High School, the leadership of the Wireless Association of South Hills (WASH), one of the four host amateur radio clubs for the symposium, has made its mission to work with students. Because of this focus, the leadership of WASH made sure that portions of the symposium were designed to appeal to middle and high school students. To that end, Richard Crow, N2SPI, was recruited to conduct a hands-on educational project during the symposium. Assisted by his wife Sally, KC2CCE, Richard led student satellite workshops. They mentored a group of eager middle school and high school students in building their own satellite downlink antennas, which successfully received SO-50.

Conclusion

Along with WASH, the symposium was co-hosted by the Breezeshooters Amateur Radio Club, Skyview Amateur Radio Club, and Washington Amateur Communications Club, all of the Pittsburgh area. From their seamless cooperation to their *espirit de corps,* their work in bringing about a successful conference was appreciated by all of the attendees. Truly, they set the standard for hosts of future symposiums.

Speaking of future symposiums, the AMSAT Board of Directors has announced that the 2008 AMSAT Space Symposium will be held in October in Atlanta, Georgia. This symposium will be named the "2008 Harry Yoneda, JA1ANG, AMSAT Space Symposium" in memory and honor of Harry, who became a Silent Key on October 8, 2007. Harry was both a former AMSAT board member and a founding member of JAMSAT, as well as a close friend of many in the AMSAT organization. Details on this year's symposium will be posted on AMSAT's website (http://www.amsat.org) as they become available.

In summary, the AMSAT leadership's announcements of new opportunities and the technical discussion inspired everyone. Truly, it was a revolutionary weekend—not only for the Amateur Radio Satellite Service, but also quite possibly for the Amateur Radio Service as a whole.

Cansat: Hands-On Experience Learning about Satellites

In this article KD4HBO expands on an idea that Bob Twiggs, KB6QMD, first thought of in the 1990s, that of recycling soda cans for use in space exploration educational projects.

By Ivan Galysh,* KD4HBO
Stensat Group LLC

Prof. Robert Twiggs, KE6QMD, of Stanford University, developed the concept of cansat in the late 1990s. The purpose of cansat was to allow students to experience a space program on a small, affordable scale. A cansat is a simulation of a satellite the size of a soda can. Students build a satellite that can fit into a soda can and perform some mission. The cansat is launched in a high-power rocket to an altitude such as 12,000 feet and is ejected from the rocket. The cansat floats back to Earth for several minutes, performing its mission and transmitting telemetry or accepting commands to perform specific tasks.

The first cansat launch occurred in 1999 in Black Rock, Nevada. Over time, the cansat concept has spread around the world. It has been used as a stepping stone to the cubesat satel-

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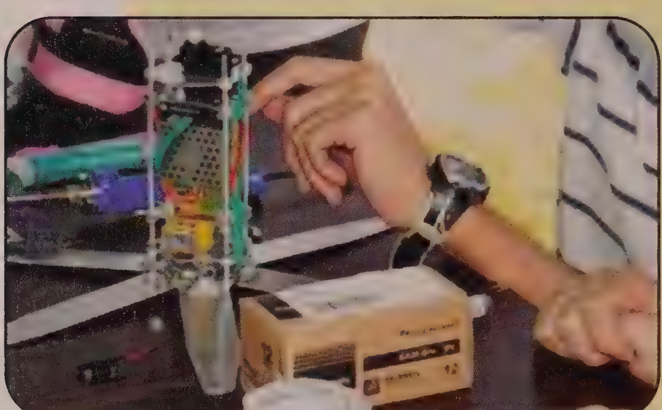
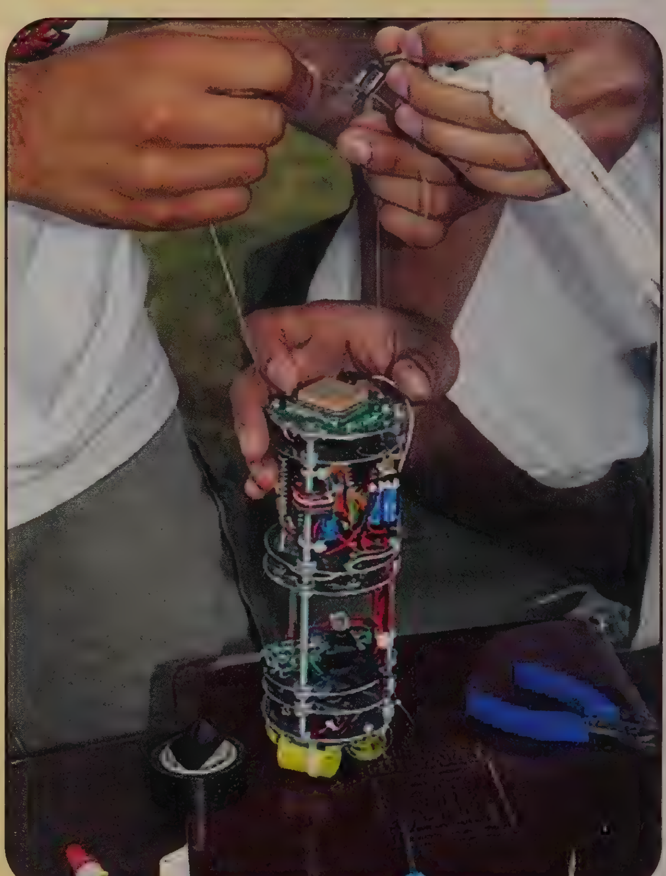
(This article is reprinted courtesy of AMSAT and the author and first appeared in the 2007 AMSAT Symposium Proceeedings.*)*

Photos from the third annual cansat competition in Amarillo, Texas. (Photos courtesy of the author)



The electronics inside one of the cansats.

One of the groups ready to launch a rocket with a cansat.



Another cansat.

lite, which was also developed by Prof. Twiggs. Cubesats are picosatellites that can be as small as a 4-inch cube weighing a kilogram.

ARLISS

ARLISS, A Rocket Launch for International Student Satellites, is where cansat started. Every year since 1999, Stanford University, led by Prof. Twiggs and the AeroPac rocket club, has launched cansats up to 12,000 feet for students from various schools, including some in Japan. The launches are held in Black Rock.

The ARLISS launch has been attended by high school and university teams. The event is not a contest, but rather an event providing students with the opportunity to have their cansats launched to high altitudes. The students design and build their cansats to perform a mission they define themselves. The Aeropac rocket club provides the rockets and launch support.

Cansat designs have ranged from simple temperature-measuring devices to robotic types.

National Cansat Competition

In 2004 a university-level cansat competition was created. The competition organizational committee consisted of the American Astronautical Society, American Institute of Aeronautics and Astronautics, Naval Research Laboratory, NASA Goddard Space Flight Center, and the Jet Propulsion Laboratory.

Each year the committee defines a mission for the competition, with the current theme being planetary exploration. Universities around the country apply to be in the competition and start designing their cansats. The teams are required to hold preliminary design reviews and critical design reviews with the committee members, usually by teleconference. In June the teams go to Black Rock and launch their cansats on rockets provided by the competition committee.

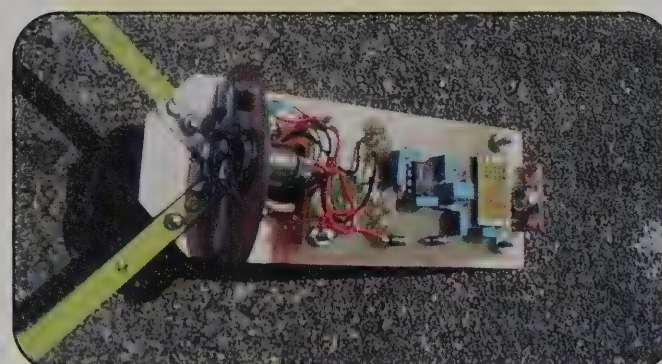
The first national competition was held in June 2005 near El Centro, California. Seven teams applied and only three teams came to the launch. The mission was to measure atmospheric pressure and temperature, and to measure the distance and direction from the landing site to the launch site. None of the teams recovered their cansats, which were launched to 5000 feet.

The second launch was held in The Plains, Virginia with the same mission but a lower deployment altitude of 2000 feet. For this event 13 teams applied and seven made it to the launch. Two teams successfully completed the mission.

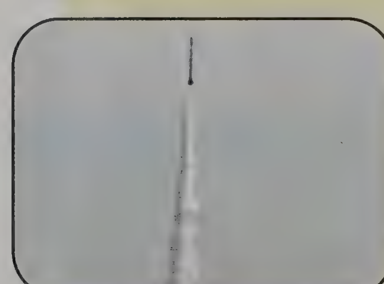
In 2007, the third competition was held in Amarillo, Texas. The mission was changed to require more mechanical and aerospace engineering efforts and less electronics. The cansats had to land and be in an upright position. Twenty-six teams applied and 15 teams attended the competition, including a team from Hawaii. One team successfully completed the mission, with a second team almost completing it. Vegetation was an issue.

Pictures from The Netherlands cansat competition.

Getting ready to track the rocket launches



A PC board inside ofne of the cansats.



A rocket launch.

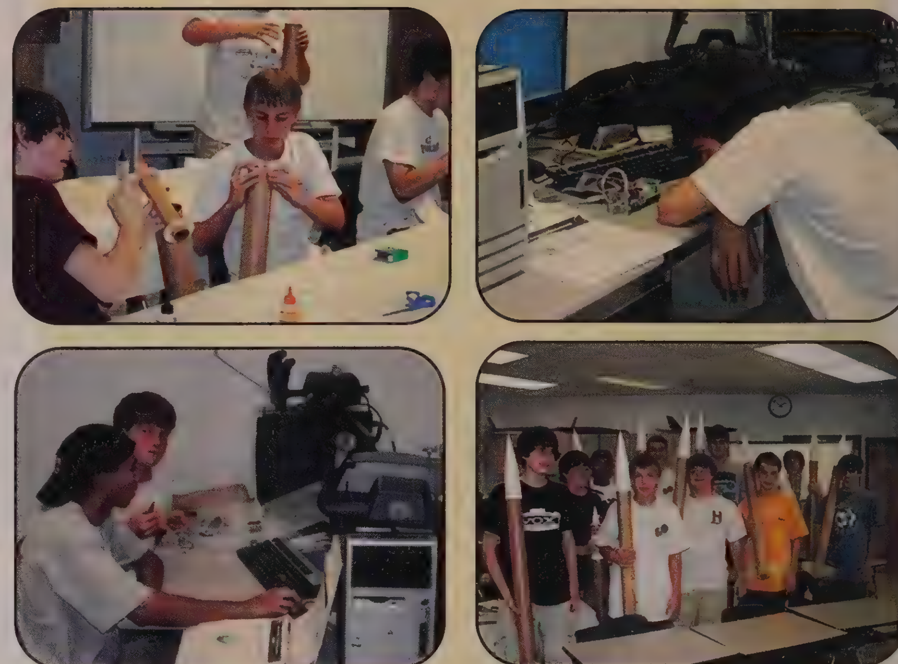
Cansat Around the World

The cansat concept is spreading around the world. The largest organized international event is held in The Netherlands. Delft University of Technology and the ISIS (Innovative Solutions in Space) company have organized a national cansat competition similar to the U.S. competition. Their purpose is to increase interest in exact sciences and technology and enrollment in the Bachelor and Master studies at Delft University. Other organizations involved include The NAVRO (Dutch Amateur Association for Rocket Research), which organizes the launches; DARE (Delft Aerospace Rocket Engineering), which develops, builds, and launches the rockets; and the WO-Sprint fund, which stimulates the competition through its Sprint Program. For the next competition, the winner will travel to the United States to compete in its event. More information can be found at <http://www.cansat.nl>.

High School Cansat Launch

For high schools that want to attempt simpler missions, a regional cansat launch will be held in Maryland in April 2008. This event is open to high school students only. The documentation is less stringent than for the university competition. The

mission is simpler, but it does require the students to include most subsystems of a satellite in their cansats. The students have to build a ground station. They get to build the rocket to launch their cansat. A rocket motor will be provided at the launch, and the teams will display a poster describing their cansats and missions. More information can be found at <http://www.foge.org>.



Students working on the cansats and rockets at the Federation of Galaxy Explorers' sponsored summer camp in Chantilly, Virginia.

Cansat Summer Camp

The Federation of Galaxy Explorers, a nonprofit organization dedicated to teaching kids about space and technology, operates a summer camp for high school students in Chantilly, Virginia. It teaches students about satellites, what makes up satellites, and how they are built and tested. During the week-long summer camp the students work on cansat kits, which include many of the components of a satellite. They also build a 3-inch diameter rocket to launch the cansats.

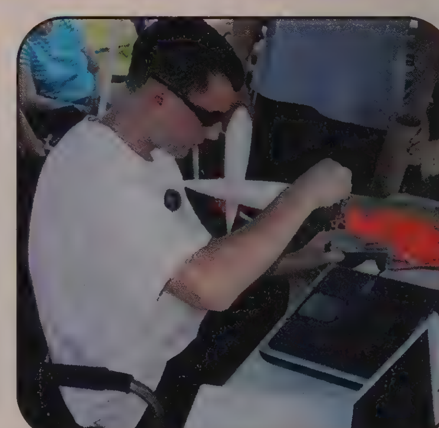
During the last camp experience, the first day began with a discussion of the sub-systems of a satellite. The Clementine satellite designed and built by the Naval Research Laboratory was used as an example. Many of the Clementine satellite components were compared with the components of the cansat. The cansat had all of the main subsystems—the aluminum structure, power subsystem, the data-handling unit, communications subsystem, and the attitude determination and control subsystem. The students were introduced to basic orbital mechanics and learned about the different types of orbits. They used the Satellite Tool Kit software from AGI to visualize the different types of orbits and modify the orbital elements to see the effects. The students started assembling the cansat kits and programming the data handling unit.

On the second day, the students continued programming the data-handling unit. By the end of the day, the students had learned how to use the analog-to-digital converter and convert the solar-panel measurements into voltages values. The students also started building the rockets. Each student received a rocket kit. The kit was custom designed by Hangar 11 using Public Missiles components.

On the third day, the students started experimenting with the gyroscope. They installed the gyroscope and wrote software to measure the voltage from the gyroscope. The software then calculated the rotation rate that was linearly proportional to the voltage generated by the gyroscope. The students also learned how to program the data-handling unit to control the radio transmitter. GPS data processing was also performed that day. In the afternoon, the students went outside with their cansats and tested the GPS receivers. During the day the students installed all three fins on their rockets. Fifteen-minute epoxy was used to keep the students from building the rockets too quickly.

Thursday included final programming, cansat check out, completing the rockets, and preparing them for launch. The students also experimented with a two-axis magnetometer. The magnetometer used a different type of interface called I2C. I2C stands for Inter-Integrated Circuit Bus. The I2C bus was developed by Philips Semiconductors to provide an easy way to connect a processor to peripheral chips. The magnetometer interface behaved similar to a serial EEPROM with an I2C interface. The magnetometer measured the Earth's magnetic field and generated a heading value referenced to magnetic north.

Saturday was the launch day. The launch was held at Great Meadow in The Plains, Virginia, the same field that holds the Team America Rocket Challenge. The students showed up at around 10 AM with their parents. Praxis Inc. provided lunch and T-shirts for everyone. The



Prepping for the cansat launch at the summer camp.

ground station was set up. One student sat at the computer to monitor the telemetry, and another student held and pointed the antenna toward the cansat. The first rocket was prepared for launch on a G80 motor. The rocket parachute was packed above the piston and the cansat was placed on top. The nose cone with its parachute was then placed on the rocket.

After the rocket was placed on the launch pad, a final telemetry check was made. The rocket was then launched, and the student holding the antenna pointed the antenna toward the cansat as it drifted back to the ground. With little wind, the cansats did not drift very far and were eas-

Launching a cansat.

ily recovered. All five cansats were successfully launched, although three rockets did crash after deploying the cansats. Some configuration changes to the rockets improved the recovery. One student added a video camera to a cansat. He even built a Yagi antenna. The cansat launch went flawlessly and the video worked. The video wasn't clear, but there were times where the landscape could be seen clearly.

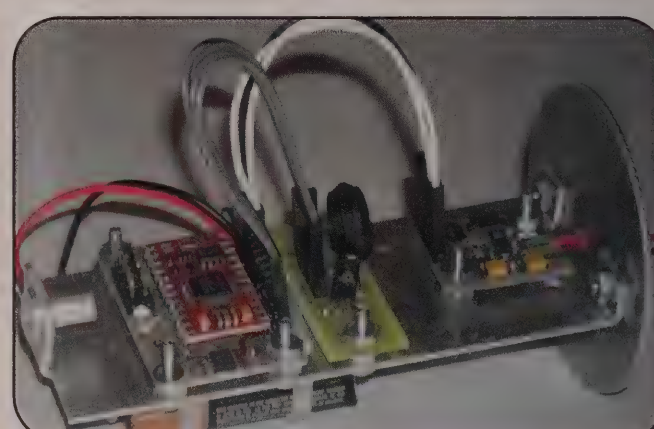
Cansat Kit

Stensat Group LCC developed the first cansat kit. The kit includes everything needed to build a cansat, with detailed lesson material. The mission of the kit is to make atmospheric measurements. The kit simulates a satellite by including many of the subsystems found in a real satellite. Some subsystems are simple, such as a 9-volt battery for the power subsystem. The kit includes a data-handling unit, a transmitter, battery power, an aluminum structure, a parachute for attitude control, and a sensor payload.

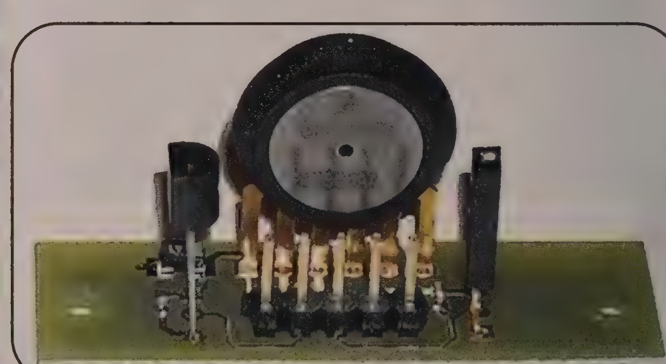
The cansat data-handling unit is a BASIC Micro processor that is programmed in BASIC. The processor includes the development software. The data-handling unit provides three analog-to-digital converter (ADC) inputs for the sensors and a port to connect to the transmitter.

The transmitter operates at 1200 baud using the AX.25 protocol and AFSK modulation. Two frequencies are available, 433.92 MHz and 916 MHz, with a power level of about 10 dBm. The transmitter accepts a universal asynchronous serial data stream and converts the data stream into AX.25 packets. The first version of the cansat transmitter has flown in actual satellites such as GENESAT-1, FCAL, and Libertad. More of the transmitters will be flying soon. Due to a part becoming unavailable, a new transmitter was designed to replace the original. The new transmitter allows for longer packets and can operate at 1200 baud and 9600 baud. It can potentially operate at 38.4 Kbaud. It is currently being designed into new satellite radio systems. A few of the new transmitters have been integrated into cubesat radio boards. The new transmitter can be configured to operate in several bands, such as 6 meters, 2 meters, 70 cm, and 33 cm. The power level is about 10 dBm.

The sensor payload consists of a single board with a pressure sensor, a temperature sensor, and a humidity sensor. All three



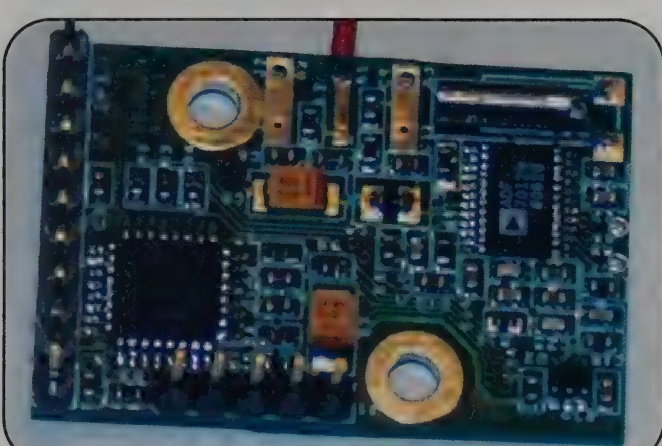
The cansat kit made by Stensat Group LLC.



The cansat kit's sensor payload with temperature, pressure, and humidity sensors.

sensors generate a voltage in proportion to what is measured. The pressure sensor is made by Freescale and has a range from 10 Kpa to 115 Kpa. The temperature sensor measures from 0 to 70°C. The humidity sensor, made by Honeywell, has a range from 0 to 100 percent. To get any significant variation in humidity measurements, the cansat needs to be launched to a high altitude, such as 10,000 feet or more. For significant temperature variation, the cansat needs to be launched to a mile altitude. The data from the pressure sensor can be used to calculate the altitude of the cansat.

The structure consists of a rectangular aluminum plate with mounting tabs. All of the electronics are secured to the plate.



The cansat transmitter.

An aluminum disk is mounted to the plate. This is the stop for the soda can. The top of the soda can is cut off. The soda can slides over the rectangular plate and butts against the disk. A hole needs to be drilled into the center of the bottom of the soda can so an eyebolt can be secured to the rectangular plate. The parachute is secured to the eyebolt.

The lesson material for the cansat is detailed. The material walks the students through each step in assembling the kit and programming it. The lesson material explains how the sensors work and how to calculate the values of the measurements. The students learn about satellite communications and telemetry. They program the cansat to measure the voltages from the sensors and calculate the values. The values are then transmitted to a ground station.

The ground station consists of a receiver and a laptop. The laptop runs a program to decode the AX.25 packets using the sound card. Most students use the AGW software. The receiver can be any ham radio receiver for the 70-cm band. A custom-built receiver is available for the 916-MHz transmitter.

Conclusion

The cansat concept is providing students around the world with hands-on experience in engineering and science. Cansat teaches other concepts besides engineering and science. Students learn to work in teams, communicate with one another, and how to coordinate their time and energies. Based on experiences at the competitions and summer camps, cansat does inspire students to pursue careers in engineering and science. Several high school students from past summer camps have enrolled in universities with aerospace programs.

ARISS Contact with the Arnold Palmer Hospital for Children

Here AA4KN writes of a first for the Amateur Radio on the International Space Station program—an ARISS contact with children who are hospitalized.

By David Jordan,* AA4KN

Since the early years of the Amateur Radio Service, the ways in which our hobby has been of service to others has continuously evolved. These evolutions have included providing phone patches between international parties and providing emergency communications in times of need. Other ways of public involvement with our hobby include introducing ham radio to the public via Boy Scout Jamborees, special event stations, and the like.

One of the more unique ways in which amateur radio has been of service to the public is by way of arranging amateur radio contacts with the public and astronauts and cosmonauts in orbit. These have taken place via the old SAREX (Shuttle Amateur Radio Experiment) program and are now taking place via its replacement, the ARISS (Amateur Radio on the International Space Station) program. Here AA4KN writes of a first for the ARISS program—an ARISS contact with children who are hospitalized.

For 11 of the young patients at the Arnold Palmer Hospital for Children in Orlando, Florida, July 17, 2007 was a memorable day that they will not soon forget. These children had the unique opportunity to ask questions of astronaut Clay Anderson, KD5PLA, on board the ISS (International Space Station) via amateur radio as it made a 9- minute 30-second pass over the United States. This ARISS contact was made possible by way of the initial efforts of AMSAT member John Rothert, KC4IYO. John had been a resident of the Orlando area for many years and the mentor for several ARISS scheduled contacts in the past.

On August 29, 2006, after securing sponsorship from the Lake Monroe Amateur Radio Society (LMARS), John applied for the scheduling of an ARISS contact with a unique institution, a place where this had never been attempted before—a children's hospital—in particular, the Arnold Palmer Hospital for Children in Orlando, Florida. Unfortunately, shortly after application was submitted, John became ill with leukemia and was not able to continue supporting the effort. However, members from the LMARS group carried forward John's efforts by working with both ARISS and the Child Life Department of the hospital in order to make this event a reality.

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(Portions of this article appeared in the August 17, 2007 [Vol. 26, No. 33] issue of the ARRL Letter.)

The Day of the Contact

On the morning of the contact members from both LMARS and AMSAT arrived at the hospital and began setting up for the QSO. Operators on hand were Northern Florida Section Public Information Coordinator Mike Welch, KF4HFC, Bob Pollack, KF4IMF, Lou McFadin, W5DID, and me, AA4KN.

This girl is shown asking her prepared question, "What do you do if you get sick in the space station?" (KF4HFC photo)

This child wanted to know what Anderson's duties are while he is on the ISS. (KF4HFC photo)

Because the ISS's orbital pass would occur over the western part of the United States, ground-station communication was provided by Santa Rosa Junior College amateur radio station W6SRJ in Santa Rosa, California. The station director is Tim Bosma, W6MU.

W6SRJ was linked to the hospital by using a phone patch, called a telebridge. At the hospital a conference phone was set up with microphones hanging from the ceiling and an additional hand microphone for more directional use during the actual contact. The audio for the event was carried over the IRLP Discovery Reflector 9010 and the Echolink AMSAT node, as is usually done for all ARISS contacts.

W6SRJ was operated by Bill Hillendahl, KH6GJV, and Don Dalby, KE6UAY. Will Marchant, KC6ROL, directed the Child Life staff in both the pre-contact preparation and post-contact wrap-up. Graham Lawton, G7EVY, was in charge of the audio for the IRLP connection. Child Life Specialist Linda Jones served as the hospital moderator for the event. The contact on board the ISS was with astronaut and flight engineer Clay Anderson, KD5PLA.

As the contact time drew closer, the 11 children were led into the setup area. Most were confined to wheelchairs and a vast array of health monitoring equipment was in use. As expected, all were very eager to get started. In order to help them relax before the contact, one of the Child Life personnel played a space trivia game with them.

After a few minutes Will Marchant, KC6ROL, began preparing the children and staff by introducing them to Bill and Don in Santa Rosa. Will explained the sequence of events that would take place during the contact, and very important, he allowed a few of the children to practice asking questions of Bill as though the contact were under way.

One of the most important aspects of any ARISS event is having the local media present. At the hospital's request, five broadcast news crews from four television stations, a radio station, and one newspaper had responded and were present to report on the QSO.

As the moment for AOS (acquisition of signal) from the ISS approached, at approximately 2:28 PM (EDT), Bill, the operator at W6SRJ, began calling Clay:"NA1SS, NA1SS, this is W6SRJ, over." After several attempts, a voice emerged from the noise and answered, "...NA1SS, over." Clay's voice was immediately greeted by an eruption of applause. Thus began a lively 9-minute question-and-answer session between the eager children and Anderson.

At Bill's direction, one by one the children began asking their prepared questions. The question-and-answer session with Clay continued very smoothly and at such a pace that soon all the prepared questions had been asked. With several minutes left in the pass, the children were asked to think up more questions for Clay. Some of these were quite thought provoking, such as one child asking, "What do you do if a solar flare occurs?" Just prior to LOS (loss of signal), a loud "Thank You" was sent up to Clay from the group and the contact was terminated. By the end of the pass, the children had asked 33 questions, possibly setting a record for any ARISS contact.

After the QSO it was the media's turn. They began interviewing the children, asking them questions such as, "Did they want to become astronauts?" and "What was it like to talk to one?" All of this media attention that the children received added greatly to the excitement of the day.

Final Notes and a Challenge

Unfortunately, for John Rothert, KC4IYO, leukemia proved to be fatal. At the time of the ARISS QSO, John was too ill to attend and he passed away within days of the contact. John's loss of his life at this time made the QSO all the more important, because among John's many accomplishments in amateur radio, this contact was his last major contribution to the hobby that he loved so very much.

Commenting on the day's activities in the hospital's internal newsletter "In Touch," Sheri Mosely, Child Life manager for Arnold Palmer Hospital, stated, "We're very excited about ARISS bringing its program to our patients, as it will be a fun activity that will lift their spirits. Talking with an astronaut is definitely a once-in-a-lifetime opportunity and one we hope they'll never forget." For all the participants, the students, and the staff, as well as the amateur radio operators who made it happen, all agree that truly, it was an ARISS QSO that will always be remembered.

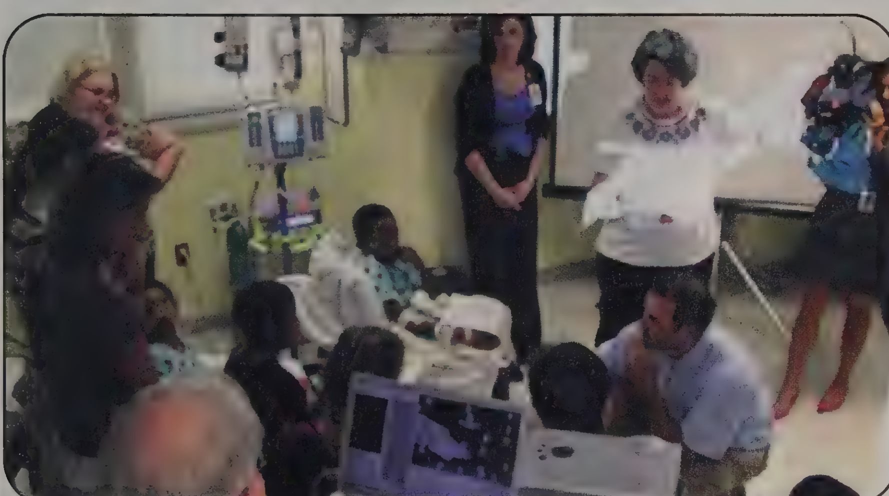
A boy takes his turn asking Clay his prepared question. (KF4HFC photo)

The local press was out in force for this ARISS contact. (AA4KN photo)

Arnold Palmer Hospital for Children, which is supported by the Arnold Palmer Medical Center Foundation, is a 158-bed facility dedicated exclusively to the needs of children. Located in Orlando, Florida, the hospital includes comprehensive, specialized programs and services for children, including acute care, adolescent medicine, a Congenital Heart Institute in partnership with Miami Children's Hospital, pediatric intensive care, emergency medicine, nephrology, and neurology, along with emergency room and trauma services. It is one of four hospitals in the United States that are dedicated to the extensive care of children. It provides safety programs to children in three counties. More details about the hospital can be found on the following website: <http://www.orlandoregional.org/arnoldpalmerhospital/index.aspx>.

I have had the privilege of witnessing and helping in both SAREX and ARISS

Another girl takes her turn asking Clay her question. (KF4HFC photo)



The boy in the dark shirt asks Clay the spontaneous question, "What do you do if a solar flare occurs?" (AA4KN photo)

school contacts in the past, but none has been as moving as this event at the Arnold Palmer Hospital for Children. After witnessing the QSO, I requested a meeting with the Child Life department at All Children's Hospital in Tampa, Florida to discuss applying for an ARISS contact at their facility. As of this writing, my efforts to make contact with them have resulted in a positive interest in the possibility of their being a possible venue for a future ARISS QSO.

After reading this account of the first hospital ARISS QSO, you might have been challenged to replicate it at your local hospital. It is my opinion that by using a telebridge configuration, any facility should be able to accommodate an ARISS contact. Therefore, I encourage readers of this article, either as an individual or as a member of a club, to pursue such a possibility by making an appointment with the director of the Child Life or children's activity department at a children's hospital in your community, or in a near-by community. Use this article as a springboard for discussing the ARISS program with them and the impact that having a personal contact with an astronaut can have on their children. Then, request that they consider allowing you to apply for an ARISS contact at their facility.

As amateur radio operators, we have this unique opportunity to make a difference in children's lives as was done at Arnold Palmer Hospital for Children. Let's take advantage of this opportunity!

The Lost Letters of KH6UK

Part 3: The Klystron Years (1960–1961)

In part 1 of this series WA2VVA discussed how he came across the lost letters of Tommy Thomas, KH6UK, along with Tommy's tropo QSO with W6NLZ. In part 2 he discussed Tommy's pioneering VHF EME activities. Here WA2VVA presents the effect that the Klystron had on Tommy's EME activities.

By Mark Morrison,* WA2VVA

After three months of vacation, Tommy Thompson, KH6UK, and Helyne were back in Kahuku by February of 1960. Tommy's first job was to prepare for 432 Mc tropo tests with John and the other West Coast hams. In prior years, Tommy would have already been prepared for the next inversion season, but his long-deserved vacation took priority. Tommy had this to say:

> The 4 long johns are sitting in the yard waiting for phasing lines and matching xfrmrs. Shouldn't take long once I get the bridge. The 432 gang is all set up and we should be ready to start tests with NLZ in a week or two now.

It was about this time when Walt Morrison, W2CXY, was well on his way to building the first 1296 Klystron moonbounce station in the state of New Jersey, and one of only three anywhere in the world (the other two being W6HB in California and W1FZJ in Massachusetts). In January of 1960, Eimac shipped Walt the 3K2500LX Klystron shown in photos A and B. This historic tube and original shipping crate are now part of the Infoage Technology Museum in Wall, New Jersey.

Walt's interest in 1296 Mc made Tommy think about the band, even though his hands were already full on 144 and 432 Mc:

> The reason I mentioned 1296 Mc to Carl (W2AZL) was that I know just what will happen when and if John and I are lucky enough to get across on 432 Mc—that guy NLZ won't let one rest until we try it on 1296 too!

Apparently, Tommy was doing more than thinking about the band, because he later wrote that a dish was coming his way. It might be possible that Tommy's visit to Washington, DC the year before had opened the door to some surplus dishes. Walt received the 15-foot dish shown in photo C from the US Air Force, and it is believed to have been manufactured by the General Bronze Corporation of Long Island, New York. Tommy's dish was probably surplus equipment from somewhere on the island. Considering this was only 1960, both dishes probably had seen radar or early satellite tracking duty.

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e-mail: <mark1home@aol.com>

Photo A. The Eimac KW Klystron delivered to W2CXY in 1960.

> Regarding the dish. Latest word is that a 28 footer is on its way and should arrive some time in March. It is just a Kennedy dish—no dipole, no mntg. Don't know just what I will do with it yet as it has no particular advantage over the Yagi array.

Although Tommy showed an interest in 1296, he wasn't thinking moonbounce at this time. Rather, he was more interested in 1296 for continued trans-pacific work with John Chambers, W6NLZ.

> Apparently the boys back there are serious about doing the m/b [moonbounce] job on 1296. More power to them. They will need it. I think it is going to take some doing even on 144 Mc. Maybe the extra antenna gain on 1296 will do the trick; time will tell.

Photo B. *The Eimac 3K2500LX Klystron used for early moonbounce work.*

Photo C. The 15-foot parabolic dish of W2CXY, Chatham, New Jersey, circa 1960.

As Walt was busy putting his Klystron power supplies together, he apparently contemplated one more shot at 2-meter moonbounce. Tommy commented on this in one of his letters:

I see you are now talking 42 foot Yagis with $2^1/2$ inch and 2 inch phase shift. Boy, that is going to be a big hunk of stuff to get up in the air—and keep up! Think I would settle for four 36 footers. As I recall Ross [Bateman] had to go to stacked rhombics before he got any results worthwhile. I agree entirely with Ross—every step has to be checked and double checked to make sure you are actually getting the gain, etc., you are suppose to. The tape of Ross's moonbounce signal was very interesting and should be able to be duplicated by a couple of serious guys. I wonder just how much gain was picked up by ground reflection. Evidently some as Ross claimed signal was best with ant aimed about 2° above the horizon. Has anyone heard their own echo overhead?

One important piece of equipment was still missing from Tommy's shack, and that was a stable receiver. This is what Tommy had to say:

Carl [W2AZL] had a good idea and even suggested he might supply us both with a highly reliable freq. standard for 144.000.000 kc. That unit he was working on plus a harm. gen. of some kind would be a nice thing to have. We must have exceptionable freq. stability—both xmtr and rcvr—even with line voltage excursions caused by transmitter load with on/off keying. The osc. Carl is working on is not affected by supply voltage variations so should be the nuts for the xmtr. Your Collins receiver may be ok in this respect too —I dunno. While my SX88 has xtal conversion oscillators it does have some shift when xmtr is keyed. I will check into this and remedy. You might check yr end too.

Tommy later expressed interest in a Racal receiver based on testing that Carl had done, most likely at the Bell Telephone Laboratories in New Jersey, where he worked.

I still haven't ordered the Racal. For awhile it looked like was gg to get an R-390 which is a vy fb Collins job but that fell thru. Still trying and if nd will have to go back to serious consideration of the Racal. Should decide one way or another in the next week or so.

By April of 1960 Tommy was still uncertain about antenna plans. He lamented not having time for 144 Mc, 432 Mc, and 1296 Mc simultaneously and remained skeptical about 1296 moonbounce for the time being. Perhaps his enthusiasm had been dampened by some insider information. In a letter to Walt, W2CXY, he wrote:

I am not as optimistic as you re 1296 m/b. For your information there is high power activity on the West Coast on 1296 Mc—and for that matter even here in KH6 land. The Eimac gang is working on it with Sam, W1FZJ, and there is a W7-W6 setting up for tests with a couple of lads in the Air Force out here. Keeping it all vy quiet so no one should beat them to the punch. For my part I would like to try it on 144 Mc first. After hearing Ross's tape and knowing we can do several decibel better job all around it goes without saying that we could make the grade with the proper installations—which are within easy reach—except for antennas. For me anyhow, 1296 is an entirely different

proposition. I have nil for this band and it will take a first class setup to do the job.

In a subsequent letter, Tommy mentioned something interesting about his antenna: "The only bad feature is being limited to only a couple of nights a month. This I don't care for."

This suggests, once again, that Tommy's 2-meter array could not track the moon. It could also explain his interest in stacked rhombics, something he seriously considered after a visit to the island by veteran moonbouncer Ross Bateman, W4AO. In 1953 Ross had used stacked rhombics to bounce the first amateur echoes off the moon. Tommy thought that such an antenna, along with a KW amplifier and parametric amplifier "al la W6AJF," might just do the job.

As Tommy contemplated the possibility of stacked rhombics, something for which he had plenty of room, he also considered a relatively obscure form of DX propagation—namely, transequatorial scatter:

> I would like to investigate the possibility of using 144 Mc when 50 Mc is open to LW3EX on TE_S. I have the feeling this might pay off. He is also working with some of the others down there using tropo scatter. PY3AB also is interested—so he writes me—and I sent him some dope. If I am going to do that kind of work tho I'll need a rotary beam. Maybe the answer is to use the dish on 432 and later on 1296 and bld big array for 144 Mc which I can rotate.

That last sentence seems to confirm that Tommy's beam was not suited for tracking the moon. At this point in time, his moonbounce partner, Walt, was focusing on his 1296 Klystron station about which Tommy commented:

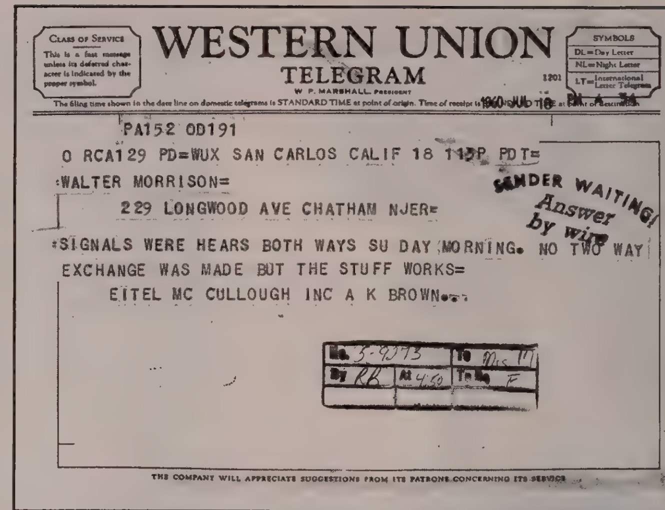
> I doubt you are gg to hv much time available for 144 m/b now if you are setting up for 1296. By the way, VWU now on job that include purchase of a 32 foot dish—which he is supposed to be able to use when it is not in operation.

In a statement reminiscent of the 1928 Presidential campaign, Tommy added "The ways things are gg, we'll have a dish in every garage!" In light of all the satellite TV dishes across the country, Tommy's prediction wasn't far off.

Tommy mentioned to Walt that Carl Scheideler, W2AZL, was just about finished with the frequency standards. He also mentioned again that if he and John, W6NLZ, were lucky enough to get across the Pacific on 432 Mc "then I am sure there will be a mad rush to get on 1296 Mc." Tommy commented, "the whole VHF gang seems to have dropped away and found other interest … wonder where W8PT is, also what is Paul, W4HHK, and W9WOK doing these days? Guess we will have to stir them up again." This last phrase is one that Tommy repeated quite often in his letters. Tommy was always interested in making the most of the amateur bands and keeping others interested as well.

By the summer of 1960 the race was heating up to complete the first moonbounce QSO. As Tommy had mentioned, several groups were already working on it, including his friend Walt. In the end, it came down to two groups, the Eimac group in California and the Sam Harris group in Massachusetts. Apparently, Walt had some inside information, too, since he predicted to Tommy that this latter partnership would be successful. Tommy had this to say:

> I see your prediction of things to come only missed by a couple of months … with the QSO on 1296 Mc m/b taking place between W1BU/W6HB on 21 July. Sorry to hear that W2CXY wasn't one of the participants … but evidently this was a joint project with several hands taking part on both ends. In any event it was a real accomplishment and the boys deserve a lot of credit.


CLASS OF SERVICE
This is a fast message unless its deferred character is indicated by the proper symbol.
WESTERN UNION
TELEGRAM
W. P. MARSHALL, PRESIDENT
SYMBOLS
DL=Day Letter
NL=Night Letter
LT=International Letter Telegram
The filing time shown in the date line on domestic telegrams is STANDARD TIME at point of origin. Time of receipt is STANDARD TIME at point of destination
1960 JUL 18

PA152 OD191
O RCA129 PD=WUX SAN CARLOS CALIF 18 115P PDT=
:WALTER MORRISON=
229 LONGWOOD AVE CHATHAM NJER=
SENDER WAITING Answer by wire
:SIGNALS WERE HEARS BOTH WAYS SU DAY MORNING. NO TWO WAY EXCHANGE WAS MADE BUT THE STUFF WORKS=
EITEL MC CULLOUGH INC A K BROWN

THE COMPANY WILL APPRECIATE SUGGESTIONS FROM ITS PATRONS CONCERNING ITS SERVICE

Figure 1. Western Union Telegram from Hank Brown, W6HB, to Walt Morrison, W2CXY.

The Western Union telegram shown in figure 1 and received by Walt from Hank Brown, W6HB, on July 18th of 1960, just three days before that first successful moonbounce QSO, shows the level of trust that existed between Walt and Eimac. Although intended to be a secret, Hank kept Walt in the loop.

Hank later wrote these words in a *QST* magazine about the role of Walt Morrison in that first successful moonbounce QSO:

> The project received a trmendous boost when Walt Morrison, W2CXY, contacted Hank and told him of East Coast interest in the undertaking. Accordingly, several Eimac u.h.f. transmitting klystrons were modified to reach a frequency of 1296 Mc and one was shipped to Walt, and another to Sam Harris, W1FZJ.

Tommy commented, "now that the ice is broken no doubt there will be a lot of activity on that band [1296] … and worldwide DX only a question of time." He added that as soon as the 432 activity was done for the year, both he and John should join Walt and the others for a KH6/East Coast QSO, something that he and Walt had always dreamed about. Since Walt had already begun work on his 1296 station a year earlier, Tommy requested information on the Klystron power supplies. He commented:

> John and I are planning to test over the usual path here even though it will not involve setting a new record [for 1296 Mc]. I would greatly appreciate any info you might have with regards to power supplies, etc., for the Klystron. Walt, this will be an entirely new field for me and I will need lots of help. Guess any plans for 144 Mc m/b will have to wait as I guess neither of us have the time to spend on that band and do a good job on 1296 too.

One of the biggest problems Tommy faced on the islands was a lack of other signals to tune in to. Thus, if a problem existed on the receiving end he might not have known about it until much later.

> With no signals of any kind to test with out here I had no way of telling if equipment was working OK or not or to check its operation from time to time as is possible when you are using the band from day to day.

In July of 1960 this proved to be a problem when Tommy's 432 Mc signal could be heard by John but not the other way around.

I suppose you have heard by now of our partial success on 432 Mc. Failure of the receiving setup here was the only thing that prevented it from being two-way … so we had to be satisfied with making it a cross-band QSO … which is little satisfaction. We had been running tests since 15 March without a sign of a signal of any kind, when on 20 July John called me frantically at 0510Z to tell me I was in 579 … I listened but heard nil … signal QSB in and out for the next several hours, and while I overhauled just about everything in the receiving installation I could not hear John's signals. Too late I found that a brand new Dow antenna relay was hanging up in the transmit position and also that feed through was paralysing my parametric amplifier diode which took several hours to recover.

Tommy reported how he was now prepared for future band openings: "Oh, well, wait until next time … if we do get a next time. I now have two complete receiving setups and can check their operation to some degree at least." Tommy then lamented how the VHF world was changing, as the gang wasn't showing up on the old frequency anymore.

How is Pappy [Carl Scheideler, W2AZL] … and what is he doing these days …never hear you guys on 14095 any more so have lost touch. Also no Art, W8KAY. In fact no one ever shows up on the old frequency anymore, so don't know what is going on with the gang.

In that same letter, Tommy mentioned a lunch meeting with Hank Brown, W6HB, the ham generally credited with the success of the first amateur moonbounce QSO: "Will QRT now as just have time to get to Honolulu where we are going to have lunch with Hank Brown and his wife who are vacationing here on the islands." This meeting was highly significant, as Hank was the person to know if you needed a 1296 Klystron at the time. In 1960 only three such Klystrons existed. One was used by Hank Brown,W6HB (HB—Hank Brown), another by Walt Morrison, W2CXY, and the third by Sam Harris, W1FZJ/W1BU. This lunch meeting was more than just pleasure as we shall see shortly. There is no doubt that Tommy's DX location would guarantee him a spot in the record books if only he could work an East Coast station on 1296 Mc.

Photo D. The Eimac Klystron amplifier (right) and the rack-mounted magnetic power supplies built by Walt (left) prior to being relocated to Infoage in Wall, New Jersey.

By October of 1960 Tommy had just about given up on 432 tests with John and Frank for the season. Tommy reported, "It had been a rather poor year for inversions due to an exceptionally windy Summer … except for the one day we got across in July…we never did really hit favorable conditions." Tommy indicated they would wait until 1961 to pick up where they left off and probably use the 432 Mc driver with a 1296 tripler to drive the Klystron. Tommy added, "Then when and if we hit favorable conditions on one band we can shift quickly to the other and kill two birds with one stone." By this time Hank Brown had arranged for Tommy to receive a Klystron, which would arrive in a few months.

Even as 1296 progress was being made, Tommy continued to express interest in 144 Mc moonbounce tests with Walt if he remained in Kahuku for another three years as this letter shows:

Regarding 144 Mc plans, Walter, if I stay over here longer than next year I would be interested in doing something on m/b on this band and put up stacked rhombics for this purpose. My second 3 year hitch ends next November and probably be busy with 1296 Mc operation during the remainder of this time so any work on 144 Mc will depend on what develops in the future.

Tommy talks about another milestone in VHF radio, that of Ed Tilton retiring as Editor of "The World Above 50Mc" after some 20 years. In December 1939, Tilton inaugurated the first *QST* column devoted to VHF. Originally called "On

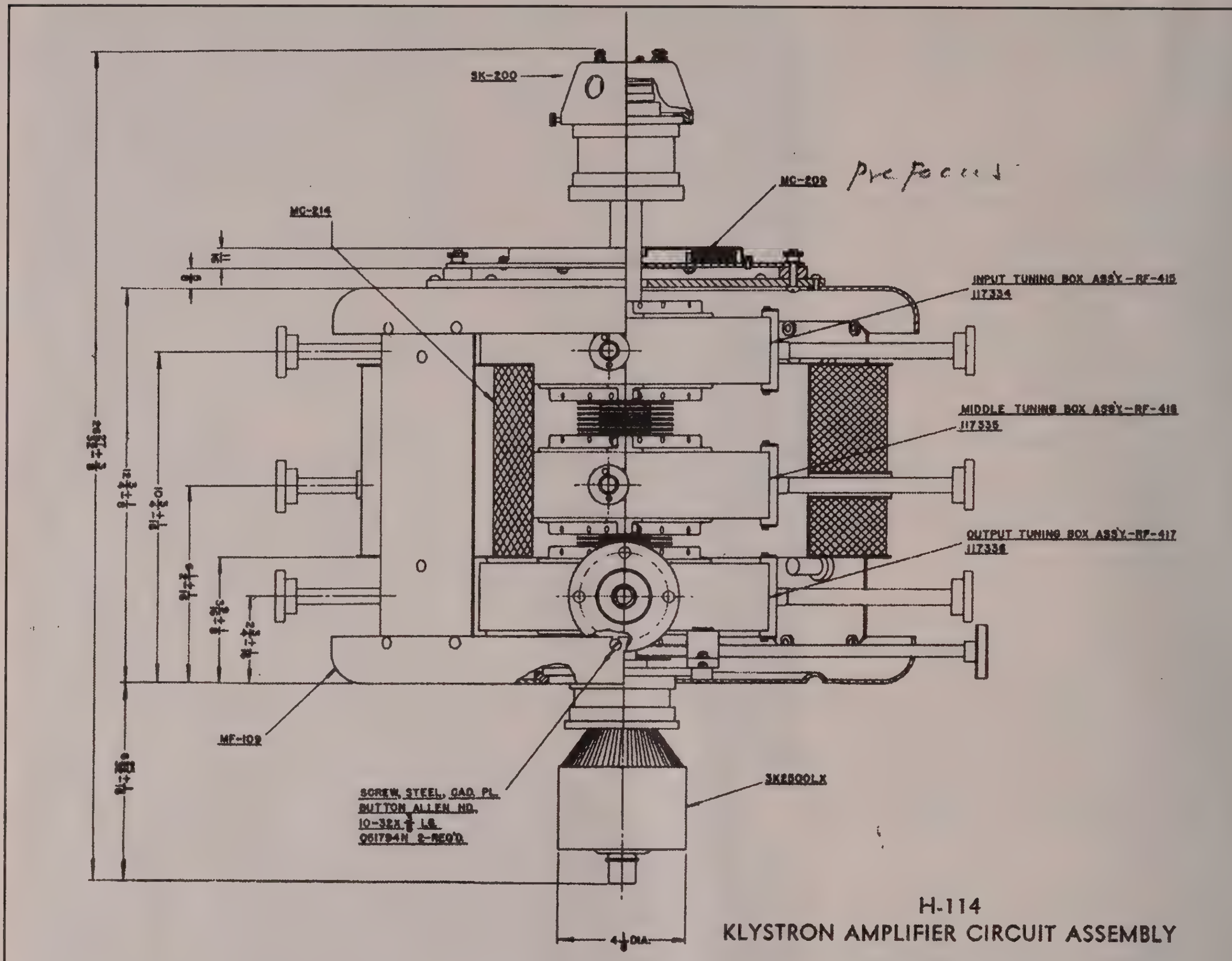


Figure 2. Close-up view of the Klystron amplifier circuitry assembly, from Eimac.

the Ultra Highs," it eventually became "The World Above 50 MHz."

Tilton edited the VHF column until he retired from the ARRL staff in 1960, reporting on-the-air activity and encouraging experimentation initially on the then 56 and 112 MHz amateur allocations, and later on all VHF and UHF bands. The UHF DX Records box—the precursor of today's standings boxes—debuted in 1940. He was the author of the ARRL's first *VHF Manual* and wrote numerous articles for *QST*. Along the way Tilton had witnessed every new development in amateur VHF communications. Here's what Tommy had to say about Tilton and Sam Harris, W1FZJ, who succeeded Ed by moving over from *CQ* magazine to *QST*:

> Looks like old Ed Tilton has finally given up the VHF column in *QST*. In some ways I am sorry to see him go and it will seem strange to read Sam's stuff there instead of in *CQ* … I am in rather a peculiar position now as I never did send any info to *CQ* but only to *QST* so don't know how it will be now with Sam there and Bob [Bob Brown, K2ZSQ] at *CQ*."

In January of 1961 Tommy reported that ham radio "had to take a back seat" due to the workload at RCAC and the birth of the nation's space program:

> We added several military circuits and are also providing some of the facilities for the Mercury Project so had deadlines to meet as well as a lot of extra work … all with a small staff.

Tommy gave Walt more information on his 1296 setup as follows:

> How are you doing on 1296 Mc? I suppose you have your dish up on a polar mount and lots of watts into it from the Klystron. It's a good thing you have a lot of room in your basement as I understand those Klystrons are quite a size not to mention the power supplies for them. My Klystron has been shipped and should be here is a week or two now … John received his the other day [bringing the total now to five] and is very much concerned about not being able to keep the input down to a kilowatt. He feels the deal is getting too xxxx commercial and wonders if it is worth the trouble … maybe he is right, hi. My dish still lays on the ground where it has been for the past few months … just no time to work on it as I said before. But I am going to mount it on something soon now come xxxx or high water. I am building the low power tripler stagers for 1296 Mc drive and AJF is building the Para Amp and Converter for this frequency for me. I have been thinking I might put the equipment in a small shack out back so it will be at the antenna … I am running out of room in the living room, hi. Wonder if you could find time to send me some dope on the Klystron installation, Walt. I have had no experience with the beast and will have to start from scratch … so will have to fall back on my old friends for help as in the past.

By this time Walt had completed his power supplies in rack-and-cabinet fashion. Photo D shows the Eimac Klystron amplifier (right) and the rack-mounted magnetic power supplies built by Walt (left) prior to being relocated to Infoage in Wall, New Jersey.

The diagram from Eimac (figure 2) shows a close-up view of the Klystron amplifier circuit, which consisted of separate tuning boxes and associated focusing coils.

Tommy apparently consulted with Walt on power supplies and added the following:

> Once I get squared away on 1296 Mc I will be ready to work you via m/b, Walt. How are you coming along ... have you heard your own echoes or worked anyone yet? I see there is supposed to be quite a gang working on these frequencies according to *QST* and *CQ* mags. I would be interested to hear what the East Coast boys are actually doing, so how about a report OB ... my best to the gang and the XYL. Has Carl switched to 1296 Mc yet?

Shortly after that letter was written, the General Electric Company held a special awards dinner for both Tommy and John at which they received the coveted Edison Award for their pioneering work in trans-pacific VHF communications (photo E). Both hams were flown to Washington, DC aboard commercial jet airliners. It is interesting to note that jet service had only started the year before, so this must have been a real thrill.

In a letter from March of 1961, Tommy thanked Walt for congratulating him on the Edison Award and described the scene this way:

> It was an unexpected surprise as it has always been awarded for other types of work, as you know. Really had a wonderful trip both ways on jets and the GE boys took real good care of us while we were there.

Tommy reported that work at RCAC had started to "ease up" and "present plans call for continuing 432 Mc tests with John until we make it a two-way and in the meantime we are getting set up on 1296 Mc." The plan was to use 432 equipment to establish contact on that band and then switch in a tripler to multiply 432 to 1296. In this manner Tommy and John could easily switch back and forth until contact was also established on 1296. Unfortunately, the work at RCAC had delayed things to the point where Tommy didn't think he'd be ready in time for the next inversion season. Tommy mentioned that Frank Jones, W6AJF, had his para amp and crystal-controlled converter about ready and Tommy had the 1296 exciter working at a few watts but not yet connected to the Klystron. Tommy received a mount for his dish and attached it to his garage. Not quite sure if it could handle the big dish due to the winds of Kahuku, he decided to add guy wires to keep it stabilized.

As with most of the Klystron moonbouncers, Tommy had concerns about the high-voltage power supply. Somewhere around 7 kV at 455 mA was required and locating a suitable transformer had proven most difficult. Shown in figure 3 is an excerpt from the Eimac 3K2500LX data sheet. Although the spec sheet implies a mere 2 watts of input drive could translate to 1300 watts output power, most moonbouncers ran this tube at around 300 watts.

An even bigger challenge was the transmit/receive relay. No commercial equipment existed for this purpose and even the first moonbounce QSO between W1BU and W6HB involved a manual operation using crescent wrenches to switch the antenna between the transmit and receive positions.

In the months following the breakthrough QSO between W1BU and W6HB, Walt took one more look at 144 Mc moonbounce. One reason might have been that 1296 had already been conquered. Another could be the amount of effort, planning, and manpower required for serious 1296 operations. Both sides of the first moonbounce QSO in 1960 involved teams of people, each with certain responsibilities. Yet another reason could be the concern that 1296 operations had become too commercial, something echoed in letters from both Tommy and John. On 144 Mc you built your own beams, experimented with element spacing, built your own converters, and worked in much smaller groups, sometimes solo. 1296 operations were different, with major portions of the station being commercial items that were either purchased or loaned, save possibly the paramp and crystal-controlled converter, and teams of people at both ends. This is what Tommy and John had to say about future 2-meter operations. Tommy wrote:

> I have no plans of any 144 Mc operation at this time, Walt, as will have my hands full with 1296 Mc for awhile. If the power restriction is ever removed from 432 Mc then I would be interested in m/b on that band. John and I spent a great deal of time while we were in Wn on this subject .... Time will tell. In the meantime mum is the word so forget I mentioned it, Walt. If I ever was going to try 144 Mc moonbounce I would put up stacked rhombics for it, Walt, as would only be interested in working you fellows back east.

In a "lost letter of W6NLZ," John Chambers wrote:

> Am about 2 weeks from turning on Klystron, sure xxxx of a lot of work, driver works fine, good 20W out. RX seems ok and paramp makes it better. But I don't know how much better. Will run RG17/U for coax, let it get warm. Still no big dish but possible deal on 17 footer. No DX activity on 144 Mc at all, haven't had 2 meters, been on with beam for almost two years. I can't see anything interesting to do on 144 Mc, takes too big antenna for m/b. If we can get rid of power limit on 432 that sounds like fine band. Also working on crystal controlled gear for 2350 Mc.

Photo E. John T. Chambers, W6NLZ (center), and Ralph Thomas, KH6UK (right), receive Edison Award trophies from General Electric Vice President L. Berkley Davis at a Washington ceremony, February 23, 1961. The award was in recognition of the trans-pacific communication by these outstanding amateurs on 144, 200, and 432 Mc. (From the ARRL VHF Manual*, 1972)*

TYPICAL OPERATION

NARROW-BAND CW AMPLIFIER (In H-114 Circuit Assembly)

Frequency	—	—	—	—	—	—	1000	1000	megacycles
Output Power	—	—	—	—	—	—	830	1320	watts
Driving Power	—	—	—	—	—	—	2	2	watts
Power Gain	—	—	—	—	—	—	26.1	28.2	db
D-C Beam Voltage	—	—	—	—	—	—	6000	7000	volts
D-C Beam Current	—	—	—	—	—	—	350	455	milliamperes
Beam Input Power	—	—	—	—	—	—	2100	3180	watts
Beam Power Efficiency	—	—	—	—	—	—	39.5	41.4	percent
D-C Body Current	—	—	—	—	—	—	40	30	milliamperes
D-C Collector Current	—	—	—	—	—	—	310	425	milliamperes
Collector Dissipation*	—	—	—	—	—	—	1030	1650	watts
Focus-Electrode Voltage	—	—	—	—	—	—	–100	–100	volts
Heater Voltage	—	—	—	—	—	—	7.5	7.5	volts
Heater Current	—	—	—	—	—	—	5.8	5.8	amperes
Magnetic-Coil Currents*									
Prefocus	—	—	—	—	—	—	0.5	0.5	ampere
Body	—	—	—	—	—	—	2.0	2.0	amperes

*Approximate values.

Figure 3. Excerpt from the Eimac 3K2500LX data sheet. Note how an input of only 2 watts would provide an output of over 1300 watts!

Another concern in the summer of 1961 was the uncertainty of how long Tommy would remain in Hawaii. By the time his three-year hitch was up in 1963 he would looking to retire back in the United States.

I don't know how much longer we will stay in these parts so have no long range plans at this time. Have another vacation coming up this next November but might possibly wait until next Spring to come back. Maybe it will be for good and maybe for a few months vacation, don't know yet as we can't seem to be able to decide where we want to settle down when we do retire. Anyway we don't have to decide yet and there are a few more things I would like to accomplish before I pull out of here. I never will have another spot like this for UHF work, hi.

The lack of local signals to tune in to continued to be a problem for Tommy. Walt suggested a tube that could be used as a frequency standard for the 1296 Mc band and Tommy expressed great interest in it.

I like your idea about using your big tube for a standard for the 1296 Mc boys back east. Only wish I had some kind of a signal to check with from time to time … sure would be a big help out here where there is not activity of any kind. A guy has to be off his rocker to go to all the trouble and expense I do to listen to tube hiss month after month. I was interested to hear about your findings on tube line-up for converters … especially how good the nuvistors are turning out to be. I am down to my last 416B now so will have to find something to replace this type with soon.

In November of 1961 Walt received a letter from Hank Brown, W6HB, regarding possible schedules on 1296. The plan was to liaison on 14095 or 7095 using the station of W6SC and a different call (W6AY) on 1296 Mc. At this point all the Klystron-based stations still had a common problem, that of switching the antenna between the transmitter and the receiver. Here's what Hank had to say:

You mentioned your antenna switching problem. This is a real stinker and I still remember the frequent use of crescent wrenches during the schedules with Sam.

One week later Walt received a letter from John Chambers, W6NLZ, sharing information about the Klystron he had received from Eimac. Walt's early start on his 1296 station made him a source of useful information to others who followed. Johns commented:

Glad to hear about the 1296 progress. As you probably know, I have had the Klystron operating for several months, but only into an 8 foot dish. No DX of course, but S9+ signals 100 miles away and over the mountains—the terror of the locals. No results from attempted moon echoes. The paramp from *QST* last year appears to work fine. The master oscillator is a Collins 40K-1. Receiver band pass 3 Kc, 500 cycles, or 125 cycles, but tuning 75A3 receiver with a 125 pass band is rough.

John added something that appears in many of Tommy's letters—namely, the practice of writing letters and sharing information on other hams had served to keep interest levels high. Here's what John had to say in a letter to Hank Brown:

What's important is that your letters have me interested again. With UPX-4 [a type of surplus equipment] it appears as though there may be something to work besides locals and KH6UK. I cannot overstate the importance of liaison—preferably 7095 Kc. Tommy and I never would have made it without good liaison. Please keep me posted as this will help keep me moving. I will do the same though there are times when it seems more pleasant to just gab with the locals on 220 and 432. . .

By the end of 1961 it appears that five 1296 Klystrons had been delivered into amateurs' hands, largely due to the efforts of one man, Eimac's Hank Brown. In the months to follow, Hank would lead these "Klystron Pioneers" in a series of coordinated moonbounce tests, which is the subject of Part 4 of this series.

Are Tropo Extensions to Sporadic-E Openings Possible?

Many of us weak-signal operators occasionally have experienced a DX QSO that is beyond what we might expect for the single-hop sporadic-*E* propagation range. WB2AMU offers a possible explanation of how it was possible to complete such a QSO.

By Ken Neubeck,* WB2AMU

Sometimes veteran 6-meter operators wonder whether there are other forces at play that seem to extend an apparent sporadic-*E* opening beyond the normal single-hop distance. This question often comes to mind with regard to long-range paths when two-hop sporadic-*E* is part of the equation but still seems to need an additional mode to carry the signal.

In previous articles presented in *CQ VHF* and *CQ* magazines, discussions were presented about "mix and match" propagation, where different modes of propagation combine to carry a 6-meter signal over specific distances. For example, during the height of the latest sunspot peak, it was observed that *F2* paths combined with sporadic-*E* openings to extend distances, and sometimes past sunset. One mix-and-match mode that would seem possible, but hard to prove based strictly on radio observations, is the combination of tropospheric-ducting paths with sporadic-*E* skip.

In this article we will explore the possibility of this combination mode as well as examine the type of geometry that would be involved if a tropospheric-duct path was connected to the end of a sporadic-*E* path. The emphasis primary will be on 50-MHz events. However, a special case of a 144-MHz event will be discussed as well.

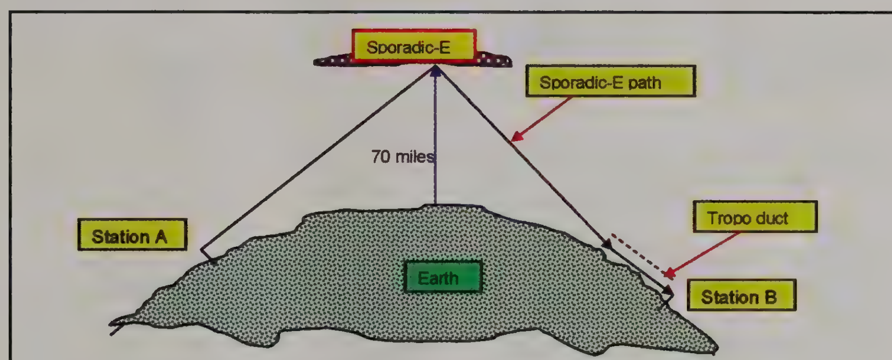


*Figure 1. Geometry of tropo extension to sporadic-*E *opening.*

Geometry of a Sporadic-*E* and Tropo Path

One path that comes to mind is the path between the northeast US and the UK during the summer months. Conventional thinking states that this path is at least a two-hop sporadic-*E* opening, and sometimes a three-hop sporadic-*E* opening. However, another model that could fit is a two-hop sporadic-*E* opening with tropo extensions on one or both sides of the path of the contact. Figure 1 shows the geometry of such a potential combination.

With long-range contacts such as these, it is almost impossible to tell by listening to the signal quality whether there may be some tropo enhancement on one end of the path. If there was such an extension to the sporadic-*E* link, it would be just as hard to determine which side of the link the tropo extension was on. Sometimes tropo has a unique fading quality of the signal that differs from the rapid fading experienced with sporadic-*E*. However, if the two modes are combined, it basically would be impossible to tell which of the modes was causing the signal fading.

Indeed, it generally is impossible by just listening to the signals to tell for sure if there is such a combination. However, a map-plot approach may actually provide clues. For example, during the heat of the summertime sporadic-*E* season, stations in much of Florida can work stations in South America and a good portion of the Caribbean on 6 meters. However, there are some Caribbean stations that are difficult for Florida stations to work, because the distance falls beyond a single-hop sporadic-*E* opening and somewhat short for a double-hop sporadic-*E* opening. It is kind of like a one-and-a-half sporadic-*E* path, and would almost be like very short sporadic-*E* skips lined up back-to-back, which is pretty rare. If two very short skips on 6x meters actually happened, there probably would be a possibility of 2-meter sporadic-*E* at the same time.

The evidence, however, appears to point to a single-hop sporadic-*E* coupled with tropo enhancement on one or both ends of the path. A single-hop sporadic-*E* opening could cover about 1000 miles. Coupled with a tropo enhancement that covers an additional 200 to 400 miles, you actually could get the effect of a one-and-a-half sporadic-*E* path!

In some parts of the world, such as the New Zealand and Australia area, natural weather conditions exist in which long-range tropo paths can occur on all of the VHF bands from 6 meters and up, particularly during the summer. It would not be unreasonable to suspect that some of these paths could actually link up with sporadic-*E* openings to provide paths between areas that normally would not be

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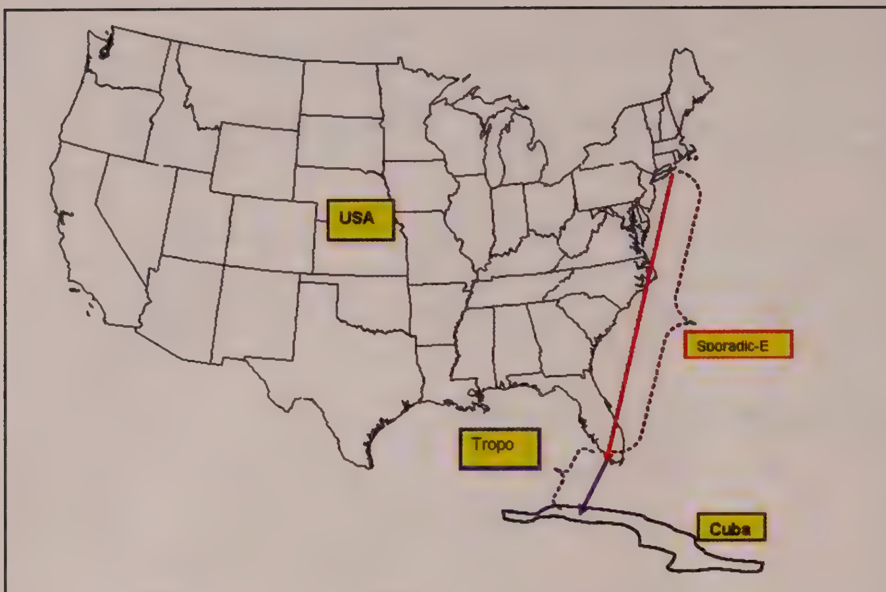

*Figure 2. Potential 50-MHz path involving sporadic-*E *skip with tropo link, Long island, NY to Cuba.*

likelihood of tropo activity farther south than southern Florida.

One of the problems regarding tropo paths in general is they often may be subjected to high amounts of fading, particularly on bands such as 6 meters. Having participated in the recent ARRL 10 Meter Contest during which there was not a lot of skip activity but a moderate amount of tropo paths, signals were moderately strong for five to ten seconds at a time before fading. Indeed, I generally have found that when tropo ducts occurred in the past, the higher VHF bands such as 144 and 432 MHz seem to have better signal quality compared to 6 meters.

covered by a single-hop or even double-hop sporadic-*E* link. With more observations made by radio amateurs in this area of the world, it will be possible to identify such events.

It would be reasonable to assume that such tropo-extensions would be more likely to occur over water paths and coastal areas around land masses, where ducting can occur from spring to the early fall.

Case Study #1

50-MHz Sporadic-E plus Tropo into Cuba

Over the 15 years that I have observed sporadic-*E* on 6 meters, one of the paths I have noted is from my location on Long Island, New York towards the south, into the state of Florida. It is not uncommon for me to be able to work into southern Florida several times during each summer season by single-hop sporadic-*E*.

What I have found a bit less common over the years, though, is my ability to work Cuba on a regular basis during the summer months. There typically are three to five active stations in Cuba, such as CO2KK, CO2OJ, CO8DM, and CO8LY. In reviewing past observations in working these stations, I found that typically signals were at best moderately strong, and I usually worked them during the late afternoon into the evening hours. Both of these facts may be relevant, because a combination sporadic-*E*/tropo event might not necessarily have the best signal strength, and the later hours of the day are generally more conducive to tropo paths (just like early morning, as well). Again, these observations do not represent conclusive results, but are just some suspicions that a combination mode of the two phenomena may be at work.

The plotting of such a potential path is shown in figure 2. For this particular example, I assumed a normal 6-meter sporadic-*E* path reaching southern Florida and covering a distance of 1300 miles. I then went with the great possibility of a tropo path being present from southern Florida over the waters into Cuba to cover the additional 200 to 300 miles or so. While tropo paths are possible at my end on 6 meters (where they can extend into southern New Jersey), I looked at the case where the path was on the southern end because of the higher likelihood of tropo activity farther south than southern Florida.

Case Study #2

50-MHz Sporadic-*E* plus Tropo into Hawaii

Inherently, one would suspect that tropo paths in certain areas are more stable in terms of duration and signal quality than in other areas. For example, during the summer the tropo path from southern California into Hawaii on the higher VHF bands is very stable and can have both long-duration and strong signals associated with it. It is not inconceivable that such a path on 6 meters could link up with a sporadic-*E* opening from the Midwest (figure 3). Certainly, the smaller wavelength VHF bands such as 144 and 432 MHz are more favorable for this duct, but 6 meters experiences it occasionally as well.

I visited southern California in May of 1992, and at that time the locals reported such an opening into Hawaii on 6 meters. It is possible that if there was a sporadic-*E* opening occurring on 6 meters into southern California at the same time from Midwest stations, that stations from the Midwest could work into Hawaii!

*Figure 3. Potential 50-MHz path involving sporadic-*E *skip with tropo link, the Midwest to Hawaii.*

I had further discussions about this tropo path occurring on 6 meters with Gordon West, WB6NOA, who has frequently observed this path from the southern California area on 144 MHz and higher. One of the problems Gordon pointed out is the fact that there is not a 6-meter beacon on Hawaii; there are 144- and 432-MHz beacons that are spotted by California hams when this path occurs. Gordon also noted (and there is information on the internet) that FM broadcasts are heard on both ends of the path, so with the FM band beginning at 88 MHz, it would not be unreasonable to assume that 6-meter signals are likely as well.

One wonders whether a sporadic-*E* opening could tie into this link during those very rare 6-meter openings into Hawaii from the northeast US during the summer months. The probability of triple- and quadruple-hop sporadic-*E* becomes less likely, but not impossible, for a path between the Northeast and Hawaii. The tropo path (which already covers over 2000 miles) linked to single-hop and double-hop sporadic-*E* would be a more likely scenario. It would be interesting to see what 6-meter contacts into Hawaii have been made over the years during the summer from both the Midwest and the Northeast.

Case Study #3

144-MHz Sporadic-*E* plus Tropo link in Europe

This is a case study involving a possible tropo link with a 2-meter sporadic-*E* opening that occurred in Europe in May 2003 as reported by Volker Grassmann, DF5AI, and Udo Langenohl, DK5YA, in the article "Very Long Distance Propagation in the 144 MHz Band" (go to: <http://www.df5ai.net/ArticlesDL/VLDP_EA8.pdf>.

This article points out a case in which a tropo path from the Canary Islands into the Portugal/Spain area occurred at the same time as a sporadic-*E* opening between Portugal/Spain and central Europe on 144 MHz on May 20, 2003. The article states that the Canary Island path into the Iberian Peninsula is an occasional tropo path that occurs over the Atlantic Ocean during the summer months, and on this particular date it linked up with what appeared to be a sporadic-*E* opening. Apparently, it allowed many 144-MHz QSOs into central Europe. Please review this excellent article for the various maps and plots that were recorded. This particular event was very well plotted because of the large number of European stations that caught the opening.

It would be very rare, but not impossible, for this type of combination (sporadic-*E* plus tropo) to occur on 144 MHz in the US. This is because 144-MHz sporadic-*E* events are very rare here in the US. They may appear once or twice in a summer season during intense periods of ionization of sporadic-*E* formations in the *E*-layer. Such an event was captured in Europe because 144-MHz sporadic-*E* appears to occur there a few more times during the summer season than in the US, and because of the large number of active hams on 144 MHz in Europe. One can argue whether there are more active hams on 144 MHz in Europe than in the US, but regular monitoring of the 144.200-MHz frequency in the US shows a significant lack of activity, making it harder to capture a sporadic-*E* event.

Based on previous articles and reports, an area of the world that sees moderate levels of 144-MHz sporadic-*E* activity is Japan. Since Japan is surrounded by water, there most likely also would be some tropo paths that exist that could link to sporadic-*E*. The problem becomes the great lack of VHF activity in the countries that surround Japan. At best, an SWL on the FM broadcast band could provide some information in this regard.

The same is true for the New Zealand/Australia area. Hams have recorded many long-distance contacts on 6 meters, 144 MHz, and 432 MHz where tropo seems to be the primary mode and sporadic-*E* events could be at play on occasion for the lower VHF frequencies.

Summary

Why is this phenomenon so important to understand? While the occurrence of tropo ducting is one of the easier VHF modes to predict, it also has its nuances, as described in this article. It would seem likely that it must be in play when certain paths occur on 6 meters, and as described in the last case study, on rare occasions on 2 meters. Again, increased activity on the VHF bands would help capture more of these events when they happen. A key component of this is the use of internet spotting and alerts.

I will continue to revisit this subject in the future with the hope of gaining additional observations, and I welcome hearing from VHF operators in different parts of the US and the world with regard to their observations.

Non-Noodling Rover Masts

Whether it's via rover operation or supplying emergency communications, the portable station operator often finds it difficult to reliably erect an antenna up more than about 15 feet. Here WB6NOA reviews the BlueSky Lite mast for its ability to fill the height needs of rover operators as well as portable emergency communicators.

By Gordon West,* WB6NOA

Ham radio operators know all too well the word "noodle"—*the unpredictable, unsteady bowing* of light-weight mast sections. As VHF and UHF rover operators are aware, getting your antennas higher than the local scrub likely requires non-noodling, stout mast sections capable of supporting even a rotor on top.

"We had our long boomers up and playing at 40 feet with absolutely no noodling," comments Bill Alber, WA6CAX, referring to the BlueSky Lite mast system (http://www.BlueSkyLite.com) available from W4RT Electronics (http://www.W4RT.com). Barry Johnson, W4WB, of W4RT Electronics, was so impressed with these made-in-the-USA mast systems from BlueLite that he brought them in for distribution at W4RT.

The blue anodized-aluminum mast systems are manufactured in Florida, originally intended for the public-safety market after a hurricane or tornado has ripped through town. The quickly deployable system is "ready to roll," in a professional-looking 54" × 14" × 14" three-wheel carry bag with fiberglass runners to slide easily into a pickup truck. During a recent Field Day, preceded by the ARRL June VHF QSO Party, we deployed the mast system to support everything from a Hi-Q motorized dipole system; followed by a pair of stacked boomers, including rotator; and finally tested with a Hex beam covering 6 through 20 meters.

For one test, during the VHF QSO Party, we compared mast rigidity of two 30-foot mast systems, supporting Chip, K7JA's homebrew copper-water-pipe 6-meter beam. With conventional mast materials, numerous sections of guy rope were required to keep Chip's beam steady. With the BlueSky Lite 30-foot mast kit, only a single set of (supplied) guy ropes to the included guy ring was necessary to keep this DX homebrew biggie aloft.

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Photo A. Tom Mackay, W6WC, prepares to assemble the BlueSky Lite mast for a southern California 2007 Field Day operation. (WB6NOA photo)

The BlueSky Lite 30-foot mast kit includes the following components, compartmentalized in the heavy-duty Cordura® rolling bag:

- Seven blue anodized-aluminum mast sections, 2.75-inch OD, 48 inches tall, predrilled for locking pins (supplied)
- Complete UV-resistant black guy-rope system, with collars and professional ground stakes
- Two-pound hammer for the ground-stake task
- Pre-mount top-section antenna pole, 24 inches, with generic antenna mounting plate (see paragraph after list)
- Base plate for ground mounting, including base plate stakes and the 2-lb. hammer
- Lock-hitch pins for securing poles together
- Lock-hitch pins for securing guy rings
- Detailed instruction manual
- Optional trailer-hitch mount and mast adapter

The top-mount flat mounting plate has been pre-drilled to accept an electric rotator assembly (flat), or to accommodate nearly any configuration of U-bolts to

Photo B. The BlueSky Lite mast sections slip together and lock in place in seconds. (WB6NOA photo)

Photo C. This heavy-weight homebrew 6-meter beam "noodled" on a conventional mast but stayed steady on top of the BlueSky Lite mast. (WB6NOA photo)

secure a beam or horizontal mast section for a pair of VHF/UHF phased beams. There are so many holes in the supplied top plate that there is little chance you would ever need to drill any more for almost any type of rotor or U-bolt

Each blue anodized-aluminum mast section slips and interlocks into the next section so they won't turn within each other. You can use as few or as many of the sections as you need to get your VHF/UHF antennas up in the air when operating rover.

"We have seen ham radio operators configure the antenna to 30 feet with more than 20 lbs. of antennas and the rotator on top," adds Scott Vanover, of BlueSky Mast, Inc., parent company of BlueSky Lite, LLC.

The sturdy ground plate, with the supplied ground stakes, keeps the base from jumping out of position, but allows the base to hinge the masts up. For rovers, you may wish to order the optional trailer -hitch assembly, which would allow the mast sections to simply slip in and secure.

"I like the BlueSky Lite with the optional trailer-hitch mount on my Blazer and my Hex-Pac (www. Hexbeam. com), which allows me to put together a monoband Hex beam in 10 to 15 minutes, covering any band from 6 meters through 20 meters," comments Barry Johnson, W4WB.

"The 20-meter beam weighs just over 7 lbs., and I can get it up in the air with the trailer-hitch BlueSky Lite mast system all by myself. Now I will be more willing to visit the in-laws," adds Barry.

In looking over the complete mast system, it looks as if BlueSky Lite is meant to replace the common, heavy, green, military mast sections. If you have worked with those military mast sections, you will appreciate the precision of matching and connecting these anodized aluminum mast sections and disconnecting them without jamming. Also, of course, like their military heavy mast counterparts, BlueSky won't noodle!

Photo D. The sturdy mast bag rolls easily on the oversize wheels. (WB6NOA photo)

"Since 9/11 and Katrina, it has become apparent that mobile solutions are needed for mast deployment, not just at the military level but at all levels, including state and local government, FEMA, Red Cross, and amateur radio," comments Scott

Photo E. BlueSky Lite 30-ft. antenna mast kit as it comes from the manufacturer. (BlueSky Lite photo)

Photo F. The safety-wire locking pin keeps the interlocking poles safely together. (BlueSky Lite photo)

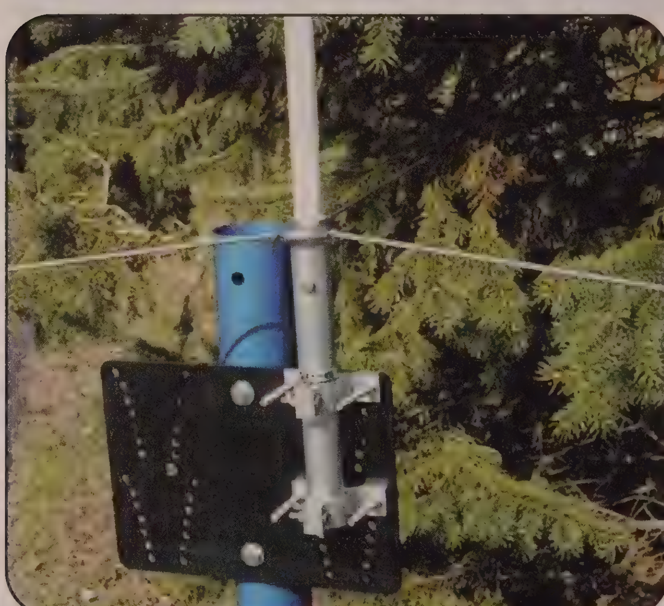

Photo G. BlueSky Lite universal antenna mounting plate holds a ground-plane antenna in place. (BlueSky Lite photo)

Photo H. The base plate of the BlueSky Lite antenna mast. (BlueSky Lite photo)

Vanover, of BlueSky. "Our BlueSky Lite masts were developed to bridge the gap that exists between military requirements, and commercial budgets by offering an economical mast to support the commercial needs of light duty portable antenna applications."

" I figured the mast would support the Hex beam, and probably the Yaesu G-1000 DXA rotor mounted at the top of the mast, with everything weighing around 70 lbs., and was quite surprised that it went up as easily as I had hoped," says Barry, W4WB. This larger-than-usual assembly of the 40-ft. diameter Hex beam up 50 feet took 12 people but only 15 minutes to get it up in the air. Barry's K4BFT team made almost 1100 QSOs on 40 meters SSB during Field Day, an impressive score for using an antenna that went up so quickly from scratch, thanks to the aluminum masting.

The suggested retail price of the BlueSky Lite 30-ft. commercial/amateur radio mast system is $795, and this includes the sturdy triple-wheel bag for easy transport. Total weight is 58 lbs., but once you roll it out of the back of the pickup, one person can easily bring the mast system over rough ground into position for setup. This system is a keeper non-noodler for the serious VHF/UHF rover.

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

RDF Protects Lives, Provides Fun, and Promotes Goodwill

"Thanks for all of the fun and experience that I have gotten through Amateur Radio Direction Finding (ARDF). It really paid off this week!" That's what Sam Vigil, WA6NGH, wrote in an e-mail that I received. He was referring to the radio direction finding (RDF) skills he developed in recent years that made him a key player in finding a lost Alzheimer's patient. When persons with dementia wander away from home, most are recovered within two miles. However, this 83-year-old victim traveled over 16 miles, but I'm getting ahead of the story.

Sam and his wife Eve, KF6NEV, were among the first to volunteer when Project Lifesaver began in their area three years ago. About 35 local citizens with Alzheimer's disease and developmental disabilities are wearing wristband transmitters that can help searchers quickly find them if they wander away from home. Just like wildlife research radio tags, these transmitters emit 25-milliwatt pulses at about 1-second intervals on individually assigned frequencies near 215 MHz.[1] Sam and others have spent many hours in training to rapidly perform RDF on these pulsed signals from the air and on foot.

RDF Rescues a Biker

The San Luis Obispo Project Lifesaver team was called into action on December 10, 2007 to find a Pismo Beach man in the first stage of Alzheimer's disease. "He is very fit physically," Sam wrote. "He has good long-term memory, but is deficient in the short term. His wife reported him missing when she came home from work at 5 PM."

Sam continued, "Eve and I responded with three other direction finding teams, checking for his wristband signal on all streets for a 2-mile radius. We knew that he was on a bike, but didn't find out until about 30 minutes into the search that his range of biking in the past has been from San Luis Obispo to Santa Maria, which is 35 miles! From past testing, we knew that the range of the transmitters is only about a mile, so we needed air support. Project Lifesaver normally utilizes California Highway Patrol (CHP) or Vandenberg Air Force Base helicopters, but Santa Barbara County came through first this time.

"Eve and I boarded at Oceano County Airport at 9 PM. The orders of Incident Commander Jon Wordsworth were for our pilot to fly south to Santa Maria and work our way back north. As soon as we crossed the Santa Maria River, I picked up a weak signal. For the next 20 minutes, we followed the biker around the north side of town as we called in the three ground teams. Just as the first team got there, we had to leave to refuel, which took about 15 minutes. When we got back over town, the signal was gone!

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Sam Vigil, WA6NGH (left), with the crew chief of the helicopter team that used RDF to help find a missing Alzheimer's patient in December. (Photo courtesy of Sam Vigil, WA6NGH)

"As we tried to re-acquire the signal, we got a radio call that one of the ground teams was hearing it weakly to the north of Santa Maria. We headed north across the river and immediately picked it up. We were not able to see the biker, even with the Night Sun searchlight and night-vision goggles. Nevertheless, we were able to vector in the ground teams with our bearings.

"By then, the patient had reversed direction and was heading south again toward the Santa Maria River. The river is pretty dry, but we were concerned that if he went down into the riverbed, the ground teams would have great difficulty finding him safely. Fortunately, he was starting to slow down. At 10:38 PM, a ground team spotted him on a frontage road next to Highway 101. He was in good shape, with mild dehydration, and was medically released to his wife that night."

There is no question that RDF played a vital and possibly lifesaving role in this rescue. By contrast, Sam tells of another dementia victim in his area who wandered away in 2005: "That subject was not wearing a wristband transmitter. It took three days and two nights, over 120 searchers from four counties, and three helicopters. When found, he was near death from hypothermia and dehydration."

The standard ground and airborne RDF antenna for Project Lifesaver is a lightweight 3-element Yagi, but volunteers and pilots agree that the 2-foot long elements of this antenna are very awkward inside a helicopter. Externally mounting the Yagi is not practical because any one of a large number of aircraft might be called for a search. Sam said, "In some jurisdictions, they open the door and put the DFer out on the skid in a harness! The CHP is unwilling to do that."

WA6NGH got the idea of using a cubical quad, which at 215 MHz has square elements that are only about one foot on a side. In addition, VHF transmitter hunters have discovered that quads

Eve Vigil, KF6NEV, gets airborne bearings with a home-built 215-MHz cubical quad. Compared to an equivalent Yagi, she found that it is better performing and easier to use in the helicopter. (Photo courtesy of WA6NGH)

are less affected by nearby objects than equivalent Yagis. Sam scaled down the 2-meter stiff-wire quad design from my book[2] and optimized the gamma match. "Now we can do direction finding from the safety and relative comfort of the chopper's back seat, shooting through the Plexiglas," Sam reported. "The quad is not only easier to handle, but its performance is better than the Yagi."

Other hams involved in this search were, in alphabetical order, Mark Calcagno, KC6BAZ; Anne Marie Foster, KI6BMC; Claudia Hayner, KG6AKN; Donald "Rusty" Hobbs, N6OCR; Beth Ries-Wordsworth, WD4NGU; Dave Smee, KG6TXN; and Jason Waddell, KF6BOP.

"You don't have to be a ham to do Project Lifesaver tracking," said Sam. "Some are not. But I think that my ham background and most importantly my ARDF experience have made a difference in my ability." WA6NGH tried foxhunting for the first time at the 2003 ARRL Southwestern Division convention hunt that I put on in San Pedro, CA. After a few more local events, he entered the 2004 USA ARDF Championships in southern California. He also took to the forest courses at the 2006 championships in North Carolina.

Project Lifesaver began in Virginia eight years ago and has expanded steadily ever since. In addition to the San Luis Obispo group, I have heard from hams in Yamhill County, Oregon and Elkhart County, Indiana who are using their RDF skills in the program. For more information about Project Lifesaver in California, contact Jon Wordsworth, the State Coordinator.[3] Elsewhere in the USA, visit the Project Lifesaver International website.[4]

Lessons from the Ukraine

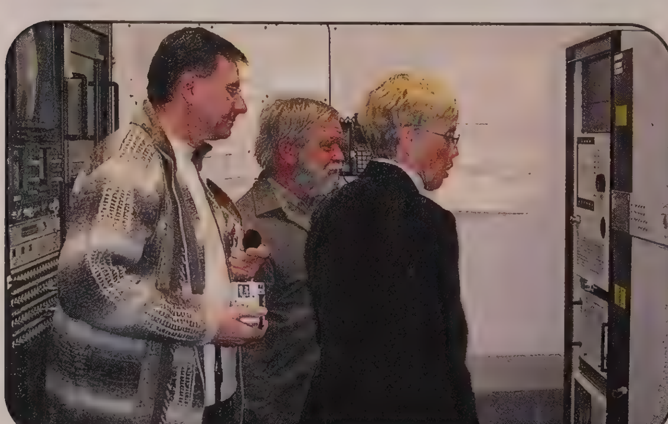
It isn't often that I get to spend an evening combining two of my favorites pastimes—ARDF and fine music. When Marvin Johnston, KE6HTS, e-mailed me to invite my wife April, WA6OPS, and me to meet Igor Lazarev, USØVA, we already had plans to get together with two other hams at a Christmas concert in Pasadena. We invited Marvin and Igor to join us at the evening event and they accepted.

In five vehicles, we all converged on the Pasadena church just in time, including Igor, who had successfully followed our directions from the Los Angeles airport with neither a ham transceiver nor a cell phone. After the concert, Igor and the group were treated to a tour of the inner workings of a pipe organ and a visit to a satellite earth station in Burbank, all while chatting about ARDF in our respective countries. It was international goodwill at its finest through amateur radio.

USØVA is an orthopedic scientist. His expertise is in the treatment of patients recovering from disease and trauma to muscles, bones, tissues, and nerves. The equivalent medical specialty in the USA is physiatry. With this background, Igor was an excellent choice to be the primary physician for the 23-member Ukrainian ARDF team. His wife Nataliya, who could not go on this brief trip to the USA, is a gynecologist who handles medical issues of the girls and women on the team.

Marvin and I peppered Igor with questions to help us understand the constant superiority of the Ukrainian ARDF program. April, who has been the Field Medic for recent USA championships, wanted to know all about treatment of sports injuries during training and competitions in Europe. Another topic was the difficulty of obtaining visas for some countries' visitors to ARDF events in the USA.

The Ukraine is the second largest country in Europe, approximately the size of Arizona and New Mexico combined, with 46-million inhabitants. When the first Ukrainian ARDF events were held near Kiev in 1957, Nikita Khrushchev was at the height of his power and this region was part of the USSR. In those days, international-rules radio-orienteering was strictly a



Igor Lazarev, USØVA (left) of the Ukraine and Marvin Johnston, KE6HTS, get a satellite uplink station tour from Christie Edinger, KØIU. (Photo by Joe Moell, KØOV)

The Ukraine celebrated 50 years of ARDF participation last year with a special event station and an award for working radiosport participants on the air. (Courtesy KARL)

Serhiy Zarubin of the Ukraine won a gold and a silver medal at the USA ARDF Championships in 2001. He took the mic at the awards ceremony to thank all for their hospitality. (Photo by KØOV)

European sport, closely tied to the military and government schools in Soviet countries. The USSR was always near the top of the medal count at the World Championships.

With the breakup of the Soviet Union, the Ukraine became an independent republic in 1991. Former Soviet countries then began competing against one another at ARDF contests, where Ukrainians were and continue to be in the top tier. At the most recent World Championships in 2006, Ukrainians took home 15 medals, including seven gold. At least one Ukrainian finished in the top five in every age/gender category on 80 meters, and in all but one category on 2 meters.

Serhiy Zarubin and Volodymyr Griedov, UT5UAZ, of the Ukrainian ARDF team came to the USA in 2001 to compete as visitors in the First USA ARDF Championships in Albuquerque, New Mexico. They took first and second place overall in their age category on both 2 meters and 80 meters. Serhiy completed the 80-meter five-fox hunt in less than 37 minutes, setting a USA Championships course record that has not been broken since.

What are the reasons for the Ukrainians' success? First and foremost is constant training. As soon as the snow clears, regular local events begin all over the country. Competitors measure their skills against one another weekly through the spring and summer. Second, the old ties to the country's schools and conscription-based military remain strong. For those in the military, there is extra incentive to do well.

The Ukraine's national championships select the best foxtailers in each age/gender category, who receive additional training and medical support as they prepare and travel together to the World Championships. National funding to support Ukrainian ARDF is down markedly from years past, but a strong program continues with volunteer support.

Stateside hams can't emulate the concentrated national training regimen of the Ukrainians, because the continental USA is 16 times larger and travel costs would be prohibitive. Our once-a-year championships have drawn radiosport enthusiasts from Santa Barbara to Boston and Seattle to Daytona. We need concentrated training in all those communities and elsewhere in our country. You can get involved by organizing ARDF classes and practice sessions in your own area, as well as by promoting the sport to your local ham clubs, schools, and Scouts.

Like our ARDF national championships, the Ukrainian nationals are open to all. Igor wants stateside radio-orienteers to visit his country this spring. Ukrainian championships will be at the end of April and beginning of May. Besides learning and competing, you can take tours of the country, including a visit to the infamous Chernobyl reactor site on the Belarus border.

An Invitation to Texas

In the last issue of *CQ VHF,* I recalled the fun and excitement of the USA's seventh national ARDF championships. If that made you resolve to attend this year's championships, you can start making plans now. Your destination will be Austin, where the Texas ARDF group and the Houston Orienteering Club (HOC) will set foxtailing courses near the 175-year-old town of Bastrop on the second weekend of May.

It's hard for non-Texans to imagine pine forests anywhere but on the east coast of the Lone Star State. However, Bastrop and Buescher State Parks, about 30 miles from Austin, are full of loblolly pines. You may hear them called the Lost Pines, so named because the area is over 150 miles from the large forests of east Texas. You could choose to believe the legend that ancient tribesmen took seedlings westward with them to combat homesickness, or you could trust the scientists who say these pines are there because of glacial activity. Pollen studies show that they started growing in Bastrop County about 18,000 years ago.

This is rolling terrain, with much less elevation change than last year's mountain sites near Lake Tahoe. Besides pines, the parks feature unusual ferns and fungi. You might encounter a deer, raccoon, or armadillo between the radio foxes. You will definitely hear and see birds, because over 250 winged species have been documented there. If running with radios and communing with nature isn't enough for you, there is an 18-hole golf course in Bastrop Park.

Bastrop Park also has small ponds that are home to the endangered Houston Toad. You may not see these 3-inch critters, because they have evolved coloration and a rough skin for protection from predators. Despite the camouflage, their numbers are dwindling. There are probably less than 4000 adults of the species left in the world, so large areas of the park are closed during the February through April mating season. That is why the championships are taking place on the second weekend of May. The toad closure is over by then, and it's not yet too hot for comfort.

HOC has produced excellent orienteering maps that will be used for this event. Bastrop Park is so popular for map-and-compass fun that HOC has placed about 100 permanent wooden markers throughout. Visitors can try their hand at classic orienteering on any day that the park is open. However, if you plan to compete there in May, don't do it yet. Bastrop and Buescher parks are currently under embargo for ARDF competitors. That means that you are not permitted to go into these woods in advance to get the "lay of the land." The goal of the embargo is for everyone at the 2008 championships to experience the park as a newcomer, with no unfair advantage of familiarity.

To give participants the option to get home in time for Mother's Day, this year's USA championships will be Thursday, Friday, and Saturday. May 8 will be arrival and equipment testing day, with a few 2-

Wet but happy, here's Ken Harker, WM5R, of Texas near the end of his bronze-medal-winning 2-meter run in the rain at the 2006 USA ARDF Championships in North Carolina. This year, he and his wife Jen, W5JEN, are co-chairs of the USA ARDF Championships in Texas. (Photo KØOV)

On her way to a gold medal, Jen Harker, W5JEN, heads out the 2-meter starting corridor in North Carolina during the 2006 USA Championships. (Photo by KØOV)

In September 2006, Nadia Scharlau of North Carolina was the first American to win a medal at the ARDF World Championships. (Photo by Richard Thompson, WA6NOL)

meter and 80-meter transmitters on the air near event headquarters. There will also be a get-acquainted meeting and drawing for starting order. The 2-meter contest will be Friday morning, with competitors starting in small groups made up of different age/gender categories, in the drawn order.

The 80-meter event will be Saturday morning with starts in reverse order, highest numbers first. After everyone returns from the woods and the results are tallied, medals will be presented.

Organizing co-chairs for the 2008 USA Championships are Kenneth and Jennifer Harker, WM5R and W5JEN, respectively. They competed at the USA Championships in 2003, 2005, 2006, and 2007. Each won medals on both bands at the 2007 USA ARDF and IARU Region 2 Championships near South Lake Tahoe. Ken and Jen organized the first Texas ARDF Championships in October 2005.

It will be easy to fly to the 2008 USA Championships, thanks to the new Austin-Bergstrom International Airport (IATA code AUS). It is 25 miles from the park and provides non-stop service from 46 airports around the country. AUS was proclaimed the best domestic airport in North America for 2006 by Airports Council International.

Registration for the 2008 USA championships should be open by the time this issue reaches you. The Texas ARDF website[5] is the place to go for detailed schedules, frequencies, lodging information, and registration forms.

As always, the USA ARDF Championships will be open to anyone of any age who can safely navigate the woods. A ham radio license is not required, but it greatly adds to the fun. Each person competes as an individual; there is no teaming or human assistance allowed on the courses. GPS help isn't allowed either! Also, of course, you can't use wheeled conveyances.

You are responsible for providing your own RDF gear. If you inquire ahead of time, you will probably find equipment that can be loaned to you. Only non-radiating receivers are permitted. Transmitting on the course is forbidden, except in an emergency.

If you have never participated in an international-rules transmitter hunt, be sure to read up on the sport in past issues of *CQ VHF* and at my website.[6] You will find the basics, rules, signal parameters, and equipment ideas, and you can determine your own age category. Be sure to look over the photos from our championships of previous years to see what the well-dressed radio-orienteer wears.

By happy coincidence, part of this event will take place during the CQ Worldwide Foxhunting Weekend. Even if you can't travel to Texas, be sure to arrange some foxhunting fun in your home town on that weekend and send the results to me for an upcoming article in *CQ* magazine.

From Austin to Seoul

As in previous even-numbered years, the USA ARDF Championships are taking place in the spring so that participants can qualify for the USA's World Championships team. This year's team positions will be offered to best performers in each age/gender category at the upcoming Texas event and last September's event near Lake Tahoe. Only three persons per category may be on a nation's team. Team members will travel to South Korea for the 14th World Championships of ARDF from September 2–7.

This is the first time that the Korean Amateur Radio League (KARL) has hosted the World Championships, and it's only the second time that the World Championships have taken place outside Europe. KARL has selected forested sites in the Gyeonggi province, about 30 miles from Seoul. Participants will be housed in a nearby resort hotel.

After invitations to join Team USA are extended to USA Championships winners, any remaining positions are open. However, individual applications directly to the Korean organizers are not permitted. Each country's team and visitor roster must be submitted by its national ARDF Coordinator.

An individual entry fee of US$400 covers lodging and food for the entire World Championships competition period plus a sightseeing day and souvenirs. Team USA's competitors and visitors are responsible for this fee plus their own transportation to and from Seoul.

If you are interested in traveling to the 2008 World Championships as a competitor or spectator from the USA, please contact me by e-mail or postal mail to the addresses at the beginning of this column. If you have not been on Team USA before, include your full name, callsign, mailing address, home phone number, and date of birth. Canadians should contact Joe Young VE7BFK.[7] Persons from any other North or South American nation should contact Dale Hunt, WB6BYU.[8]

At the last World Championships in Bulgaria two years ago, the USA was awarded its first medal.[9] Perhaps you have what it takes to be our next medalist. Start practicing and training now. I hope to see you at the USA championships in May.

73, Joe, KØOV

Notes

1. For more on small pulsed transmitters and receivers in the 200-MHz region, see "Homing In" in the Spring 2006 issue of *CQ VHF*.
2. Moell and Curlee, *Transmitter Hunting —Radio Direction Finding Simplified,* Chapter 4. Information at <http://members. aol.com/homingin/THRDFSinfo.html>.
3. <esgo@aol.com>
4. <http://www.projectlifesaver.org>
5. <http://www.texasardf.org/usa2008/>
6. <http://www.homingin.com>
7. <ve7bfk@rac.ca>
8. <wb6byu@arrl.net>
9. See "Homing In" in the Fall 2006 issue of *CQVHF.*

IARU International Satellite Forum Report

A frequency wish list and congestion on 2 meters were the main topics at the IARU International Satellite Forum in 2007. Here is ZS6AKV's report.

By Hans van de Groenendaal,* ZS6AKV
IARU Satellite Adviser

The IARU International Satellite forum meets annually to discuss issues that are of relevance to the amateur radio satellite fraternity and informs the IARU Satellite Adviser on items that should be brought to the attention of the IARU Administrative Council. The forum is hosted in alternate years in the USA as part of the AMSAT NA Space Symposium and in the UK as part of the AMSAT UK Satellite Colloquium.

AMSAT NA hosted the forum at the Pittsburgh Space Symposium in October 2007. The main topics of discussion were a frequency wish list for future allocations and congestion on the 2-metre band.

The IARU annually updates a wish list, which the organization representing all national amateur radio societies uses to form the basis for its interaction with the ITU and the World Radio Conferences. For years, the international satellite community has not produced any input for this list. However, with many recent developments, the AMSAT NA forum resolved that a wish list should be developed and submitted to the IARU for consideration.

After considerable debate, the following wish list was decided upon. Individual radio amateurs and AMSAT organizations worldwide are asked to give further input before a final list is submitted to the IARU Administrative Council. AMSAT groups on the international list will be canvassed. It will also be necessary to develop a set of justifications as to why these additional or revised allocations are important for future development. Input and comments should be sent to <zs6akv@amsat.org>.

The following are being put forth for for consideration:

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Band	Proposal
50–51 MHz	Seek new harmonised Amateur Satellite Service E-S and S-E allocation for communication and propagation research complementing existing Amateur Service requirements.
438–440 MHz	Extension to existing allocation E-S and S-E
1.240–1.250 MHz	E-S and S-E
2.300–2.330 MHz	E-S and S-E
2.390– 2.400 MHz	E-S and S-E Currently primary in USA 2 390 – 2 395 MHz and shared Primary 2.395–2.400 MHz
3.400–3.410 MHz	E-S and S-E Already available in Regions 2 and 3 This is an urgent request as current lack of allocation in Region 1 is limiting the use of this band.
5.650– 5.670 MHz	E-S and S-E
10 GHz	Satellite Service requires 10 MHz allocation. 10.360–10.400 MHz and work towards 10.450–10.460 MHz as Primary.

E-S is "Earth to Space"
S-E is "Space to Earth"

Congestion on 2 Meters

The worldwide band plan for satellite operation is 145.800–146.000 MHz, which simply is not enough to accommodate the many satellites being built.

A proposal "to permit satellites operating in the Amateur Satellite Service which incorporate linear transponders for CW and SSB activities to use, on a non-exclusive basis, the section of the 2 metre band 144.310–144.370 MHz for downlink (satellite to ground) mode only" had been rejected at the IARU Region 1 Interim Meeting in Vienna earlier in 2007.

A further proposal is now on the table for the IARU Region 1 Triennial Meeting in Nov 2008: "To permit satellites, operating in the Amateur Satellite Service, which incorporate "linear" transponders, which are generally used for narrow band non-channelized signals, to use, on a *non exclusive basis,* the section of the 2 metre band 144.005–144.045 MHz for downlink (satellite to ground) mode only, by amending the band plans in each IARU Region."

Before such a proposal can be brought forth, it will be necessary to consult with the EME (Earth-Moon-Earth) fraternity, as it was an allocation used for EME, but in general is no longer used today,

145.800–146.000 MHz Downlink Only

The presence of interfering non-amateur signals in the 145.80–146.00 MHz part of this band in many parts of the world is well documented. To prevent the retransmission of interfering terrestrial signals, satellites in the Amateur Satellite Service that plan to use the 2-metre amateur band for transponder operation are encouraged to use this band for downlink (satellite to ground) modes only, regardless of modulation type.

It was further recommended that satellite builders consider 70 cm and higher frequencies for further projects.

The next forum will be held in conjunction with the AMSAT UK Colloquium in July 2008.

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

The New World of AMSAT

In the last issue of *CQ VHF* we reviewed satellite basics. This time we will discuss the new world of AMSAT as introduced at the 2007 AMSAT Space Symposium in October 2007. Along with this comes the need for reinforcement of a "can do" attitude for amateur radio satellites and space programs.

Return to High Earth Orbit Satellites

Since the demise of AO-40, amateur radio operators have not had access to a HEO (High Earth Orbit) satellite and much discussion has taken place bemoaning this fact. Satellite builders in the various AMSATs have been trying to fill this gap as quickly as possible, but this has not been very fast. Most of the delay can be traced to one item—money (or the lack thereof). In this day and age there is "no free *launch,*" and the costs of designing, building, and testing continue to mount.

The Phase 3E program of AMSAT-DL is nearly ready to launch after a long design effort, but no affordable launch is currently available and funding for the AMSAT-DL laboratory has been curtailed. German funds *may* be available soon, but they are contingent upon the status of the Phase 5 (Mars Orbiter) program. Meanwhile, AMSAT-NA and AMSAT-UK have provided funds to keep the laboratory and design team together until the satellite can be declared "ready to launch" and be placed on the shelf until a launch can be initiated.

The AMSAT-NA Eagle Project is proceeding along in spite of some required re-design, but this is at a fairly slow pace largely due to weak funding. AMSAT-NA plans to continue this project to completion, but greatly enhanced funding is required for completion and launch. No firm, affordable launch opportunity for Eagle is available at this time. Meanwhile, design, prototyping, and testing continue in the new AMSAT-NA laboratory and other locations. Clearly, help is needed for this project to continue.

The timetables for Phase 3E and Eagle are uncertain until funding and launch opportunities can be firmed up. Hopefully, something will be found by the end of 2008.

Enter "Phase 4 Lite"! At a small satellite conference last summer, Lee McLamb, KU4OS, learned of an opportunity to partner with a major commercial satellite contractor for integration and launch of satellite payloads utilizing surplus capacity that now exists in commercial programs. AMSAT-NA officials jumped on this opportunity, prepared proposals, conducted talks, and have received the "go ahead" to announce

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potential teaming with Intelsat for this effort. This could lead to a ride(s) to geosynchronous orbit as well as other launch opportunities for Phase 3 satellites such as Phase 3E and Eagle. This opportunity is not for a "free launch," but it carries with it the potential to interest larger funding sources for the effort than AMSAT has been able to attract in the past. More details will be provided about this later.

Phase 4 Lite

Phase 4 Lite would be a payload on board a geosynchronous satellite that would provide 24/7 coverage to approximately one-third of the Earth. It would utilize the Eagle communications design to the greatest extent possible, but would not require the overhead design of items such as power systems, space frame, propulsion system, stabilization system, environmental control, etc., that would be provided by the parent satellite. Whole Earth coverage would eventually be possible, but would require at least three satellites and connecting ground links.

Hardware and software would be designed, built, and tested to high-reliability requirements that would ensure (to the extent possible) a 15-year life span in orbit. Once developed, this hardware and software would be directly available to Eagle and other projects. Frequencies and modes utilized would be optimized for the missions of the satellite and would be software defined to the greatest extent possible for flexibility. Back-ups would be provided where single-point failure analysis and other techniques indicate they are necessary to guarantee the 15-year life span of the satellite.

Primary missions for this satellite are wide area, inter-operable, emergency communications available to all agencies and education outreach. Along with these missions, other missions are possible for use by all amateur radio operators. Since amateur radio frequencies would be utilized for all missions, hams would be required for operation in all missions. Two principal reasons can be given for the choice of missions:

1. These missions would benefit all citizens of the world.
2. Since a great need is seen for these missions, funding can be raised from sources that have not before been approachable.

Ground stations for this project must be developed concurrently and must be affordable by the average amateur radio operator. User terminals (stations) must be small, portable, and reliable. More complex stations may be required for control and linking. Ground stations can be produced and marketed by AMSAT in fashions similar to those used by TAPR and others. Kits and other fabrication techniques can be utilized.

There is an opportunity for all types of hams to be involved in this project. Satellite builders, ground-station builders, fund raisers, emergency coordinators, educators, operators, etc., all are needed.

"Can Do"

For a project of this magnitude to come to fruition, development of a "can do" attitude is required. Recent correspondence on amsat-bb and in other places has shown that a lot of self-serving, "let the other guy do it" sentiment is out there. Yes, hams do have a right to have fun, too, but fun can be had along with participation in a worthwhile project that will benefit everyone. A great deal of personal satisfaction can be obtained from a job well done that benefits everyone. An attitude change from "what will you give me?" to "how can I help?" will go a long way towards reaching the goal.

Search through your personal capabilities and resources and contribute whatever, whenever, and wherever you can. Recently, appeals have gone out for designers, builders, testers, and educators. Please respond with "can do."

Summary

Building and launching amateur radio satellites is challenging, but most hams can contribute something to the effort if they will just allow themselves to think about it. No, you don't have to be a rocket scientist to participate in building amateur radio satellites. However, if you simply will allow yourself to keep an open mind and learn while doing, you may *become* a rocket scientist. Please support the AMSATs of the world in their dedicated efforts to provide us with the satellites we love and need.

I hope this hasn't sounded like "preaching to the choir," but I felt that it needed to be said. Enjoy the LEO (Low Earth Orbit) satellites that continue to operate for us, but support the return to HEO for the benefit of all amateur radio operators and the citizens of the world.

73, Keith, W5IU

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

To the Moon, Alice!

Want to go to the Moon? If you're of the Apollo generation (as, in fact, are most AMSAT members), having come of age in the shadow of "one small step," you probably hesitated less than the blink of an eye before answering in the affirmative. After all, if we can put a man on the Moon, we reason in an expression of frustration with current NASA priorities, why can't we put a man on the Moon again?

The next best thing would be to orbit the Moon, and if we can do so with amateur radio equipment on board, so much the better. Over the next few years we just might have not one, but two chances to do so. At the August 2007 Small Satellite Conference at Utah State University, a couple of interesting opportunities were discussed.

ESMO, the European Student Moon Orbiter, is an ESA (European Space Agency) initiative to deploy a spacecraft carrying a student-designed science package into lunar orbit by 2011. This third mission of the SSETI (Student Space Education and Technology Initiative) has the following four broad objectives:

- Education—prepare students for careers in future projects of the European space exploration and space science programs by providing valuable hands-on experience on a relevant and demanding project.
- Outreach—acquire images of the Moon and transmit them back to Earth for public relations and education outreach purposes.
- Science—perform new scientific measurements relevant to lunar science and the future human exploration of the Moon, in complement with past, present, and future lunar missions.
- Engineering—provide flight demonstration of innovative space technologies developed under university research activities.

As proposed, the ESMO payload would be inserted into GTO (Geostationary Transfer Orbit) on either an Ariane V or a Soyuz launch vehicle. According to the ESMO website, "from GTO, the 200 kg spacecraft would use its on-board propulsion system for lunar transfer, lunar orbit insertion, and orbit transfer to its final low altitude polar orbit around the Moon. A 10 kg miniaturized suite of scientific instruments (also to be provided by student teams) would perform measurements during the lunar transfer and lunar orbit phases over the period of a few months, according to highly focused science objectives. The core payload would be a high resolution narrow angle CCD camera for optical imaging of lunar surface characteristics.

"Optional payload items being considered include a LIDAR, an IR hyper spectral imager, a mini sub-surface sounding radar for polar ice detection, and a Cubesat sub satellite for precision gravity field mapping via accurate ranging of the sub satellite from the main spacecraft." As would be expected, several European AMSAT organizations (including AMSAT-UK and AMSAT-DL) are lending support for this exciting mission opportunity.

Not to be outdone, in the U.S., the NASA Office of Education has proposed an ASMO (American Student Moon Orbiter) to be both competitive and cooperative with the European mission. ASMO, according to NASA, "offers to next generation explorers unique opportunities for integral involvement in the U.S. space exploration program. The ASMO project will be carried out as a diverse nationwide higher education initiative by which American university students and their faculty advisors will design, build, register, launch, and own the ASMO small spacecraft and its payload."

Why would NASA risk turning over a major component of its lunar research to a group of students? During the years of the Apollo program, the average age of NASA's workforce was 26. Today, NASA employees average 47 years of age, with 25% eligible for retirement within the next five years. By bringing bright young technologists on board now, it is reasoned that NASA will have a shot at replenishing itself around the time those retirements kick in.

Both ESMO and ASMO will conduct scientific experiments in lunar orbit and very likely will employ amateur radio for telemetry, tracking, and control of their respective scientific missions. According to the NASA website: "The student-built ASMO craft could be launched to orbit the Earth's Moon in 2011 in tandem with a spacecraft to be developed by European students under a companion European Student Moon Orbiter (ESMO) program. Through coordination with ESA's ESMO program and possible spacecraft interoperability, valuable opportunities for international scientific and technical collaboration could be offered. Conceived to accommodate a 10 kg payload in a highly elliptical 2 year lunar orbit, there are numerous options for ASMO to serve as a valuable data gathering mission and technology demonstration that will enhance understanding of the lunar environment and advance the small satellite field."

Your humble Director of Education had the opportunity, at the aforementioned Small Satellite Conference, to meet with some of the student teams that are bidding on pieces of the ESMO and ASMO missions. These incredibly bright young men and women remind me a little of my fellow AMSAT members and,

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"One thing that every amateur moonbouncer knows is that it's a long way to the Moon, and until Congress sees fit to repeal the Inverse Square Law, free-space isotropic path loss is going to dominate comm. link design for these challenging missions."

yes, myself, more decades ago than I care to admit. They are mostly Aerospace Engineering students at some top colleges and universities, with their heads in the clouds in true "space cadet" fashion. Some are even licensed radio amateurs, having cut their technological teeth on CubeSat projects. However, in the areas of space communications and control, they appear to have only a limited understanding of the problems they are going to face, and little experience to apply to their solution. Here's where we come in.

To date, neither ESA nor NASA has officially requested AMSAT involvement in the ESMO or ASMO missions, respectively. However, given the likelihood of employing amateur radio frequencies, the expertise available within our ranks, and the educational focus of both missions, it stands to reason that we are in a position to offer technical assistance in the areas of frequency selection, modulation, and data-format tradeoff studies, communications link analysis, spacecraft comm. system design, ground station design and operation, and training support for the ASMO and ESMO ground crews (who, we certainly hope, will all become licensed radio amateurs some time prior to launch).

One thing that every amateur moonbouncer knows is that it's a long way to the Moon, and until Congress sees fit to repeal the Inverse Square Law, free-space isotropic path loss is going to dominate comm. link design for these challenging missions. Thus, to achieve any reasonable data rate over lunar distances, we're going to have to put our hands on some pretty big dishes in order to ensure mission success. The challenges of earth station design for a lunar mission will be explored in the next "Orbital Classroom" column.

—73, Paul, N6TX

By Bob Witte,* KØNR

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

D-Star Creates Band Planning Challenge

In the Summer 2007 issue of *CQ VHF,* I mentioned the challenge that frequency-coordinating bodies are facing with regard to coordinating digital voice (e.g., D-Star) repeater systems. The emergence of D-Star is putting pressure on the frequency-coordinating bodies to find a place in the spectrum. This challenge has caused significant debate within the ham community, and some frequency-coordinating bodies have now taken action.

What is D-Star?

D-Star (Digital Smart Technologies for Amateur Radio) is an open protocol for mixed digital voice and data, developed under the direction of the Japan Amateur Radio League (JARL). ICOM is currently the only equipment manufacturer to market D-Star radios and repeaters in the U.S. However, some hams have been homebrewing D-Star–compatible equipment.

For more information, see "D-Star Digital Voice for VHF/UHF," by Bob Witte, KØNR, *CQ VHF,* Winter 2006.

Discussion groups on the internet:
Illinois Digital Ham—Yahoo Group: <http://groups.yahoo.com/group/illinoisdigitalham/>
D-Star Digital—Yahoo Group: <http://groups.yahoo.com/group/dstar_digital/>

Frequency Coordination

Frequency coordination is a critical function for effective use of repeaters on the amateur radio bands, because repeaters are inherently fixed in frequency and usually fixed in location. Frequency coordination is a process that minimizes repeater-to-repeater interference by carefully planning separation in frequency and geography. This is a voluntary function, but has the strength of the FCC behind it. When it comes to interference issues, the FCC is crystal clear that coordinated repeaters take priority over ones that are not coordinated. Overall, it is a great example of how the Amateur Radio Service can self-regulate, with a little help from the FCC.

In many parts of the U.S. designated repeater pairs in the 2-meter band are all allocated—that is, the portion of the band designated for repeaters has a repeater coordinated on each channel. When a new request is made for a repeater coordination, there is no available frequency pair that can be used without causing undo interference to existing repeaters. The 2-meter band in the U.S. is only 4 MHz wide and serves a wide variety of interests—moonbounce, meteor scatter, weak-signal CW/SSB, FM simplex, FM repeaters, and satellite. The 70-cm band in the U.S. is 420 MHz to 450 MHz, which offers a much wider slice of radio spectrum. Still, the designated FM repeater portion of the band is also fully allocated in many areas.

2 meters	144 to 148 MHz
70 cm	420 MHz to 450 MHz
23 cm	1240 to 1300 MHz

Table 1. VHF/UHF amateur bands with D-Star equipment available (United States allocation).

Frequency coordination is a difficult and often thankless job. Potential repeater owners often come to the frequency coordinator with unrealistic expectations. They frequently do not understand the principles of spectrum management; they find an "open" frequency and want to plop a repeater on it. The frequency coordinator needs to make decisions that protect the interests of established repeaters while making room for newcomers. When the band gets full, this becomes a difficult to impossible task.

To determine your local frequency coordinating body, see the National Frequency Coordinators' Council website listed in the References section at the end of this article.

There is quite a buzz surrounding D-Star, fueled by ICOM's marketing efforts and the desire of many hams to experiment with new technology. Frequency coordinators are getting requests for D-Star repeater coordination, often for a "standard D-Star stack" of 2-meter, 70-cm, and 23-cm repeaters (see Table 1). (The ICOM D-Star system is set up to use one controller for up to four bands. A common configuration is to deploy D-Star on all three available bands: 2 meters, 70 cm, and 23 cm.)

Challenging the Rules

When faced with a problem (no repeater pairs on 2 meters), some hams start to "innovate" by carefully interpreting the FCC rules and regulations. It is an interesting process, as most of FCC Part 97 was written decades ago with a particular technical context in mind. The FCC rules are intended to last over time, but sometimes they have to be "re-interpreted" to remain relevant, or sometimes people just want to read their own agenda in the existing rules.

One argument that has recently surfaced is that D-Star systems are not really repeaters, so they aren't restricted to certain parts of the band. Since D-Star is a digital-modulation format, a D-Star repeater takes in a digital bit stream, processes it, and spits it back out. The processing causes a delay between the transmit and receive functions, so maybe this is really a "store and forward" digital system. If we interpret the rules that way, then we don't really have a repeater and we are no longer limited to the repeater section of the 2-meter band. This argu-

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A display of D-STAR equipment at the the Dayton Hamvention® (Photo by Bob KØNR)

	Operation Not Allowed per FCC Rules (2m band)
Auxiliary Operation	144.0–144.5 MHz
	145.8–146.0 MHz
Repeater Operation	144.0–144.5 MHz
	145.5–146.0 MHz

Table 2. Auxiliary and repeater operation on 2 meters.

ment was put forth to Bill Cross, W3TN, of the FCC, and Bill's reply appears to have validated the interpretation. The argument centers on the Part 97 definition of a repeater, which includes the word *simultaneously*.

FCC Part 97.3
(39) Repeater. An amateur station that simultaneously retransmits the transmission of another amateur station on a different channel or channels.

Certainly, if a system receives a transmission and stores it for a day and then retransmits it, it doesn't fit our concept of a repeater. However, what if it delays the transmission by 1 minute or 10 milliseconds? Now we are into shades of gray. Opponents of this "store and forward" argument point out that many conventional FM repeaters have a delay in their audio processing system. (This delay is used to filter out DTMF tones so they can be suppressed before they reach the transmitter.) If a short delay is an issue, then analog FM repeaters can provide enough delay to no longer be defined as repeaters. Said differently, small delays between transmit and receive signals are present in many repeaters and are inconsequential.

Another argument has been made that D-Star systems can be considered *Auxiliary Stations.* Part 97.3a defines an auxiliary station as "an amateur station, other than in a message forwarding system, that is transmitting communications point-to-point within a system of cooperating amateur stations." Perhaps a D-Star system fits this definition. If so, this opens up the 145.50- to 145.8-MHz portion of the 2-meter band for D-Star use. To understand this, we need to read Part 97 very carefully, as there is a slight difference between the 2-meter subbands that allow auxiliary and repeater operation (see Table 2). The segment of 145.5 to 145.8 MHz is allowed for auxiliary operation but *not* repeater operation. Per the ARRL band plan, this section of the band is defined as *Miscellaneous and experimental modes.* Hey, that does sound consistent with new whizzy technology like D-Star.

Both of these interpretations of Part 97 have caused heated debate among the National Frequency Coordinators' Council (NFCC), the national body for frequency coordination. The NFCC voted to ask the FCC to declare "all repeaters are repeaters" (see sidebar). That is, they reject the notion that D-Star systems should be considered outside of the repeater subband.

Local Band Plans

As I mentioned in the Fall 2006 FM column, VHF/UHF band planning really is done locally. The ARRL has a band plan that provides general guidance for the U.S., but the details are worked out by local frequency-coordinating bodies. I won't repeat that information here, so take a look at that article if you want a deeper knowledge of band plans.

Based on the demand for D-Star repeater pairs and the desire to accommodate (and even promote) the adoption of new technology, some frequency-coordinating bodies have taken action.

In Arizona, the frequency-coordinating body designated four D-Star channels in the range of 145.100 to 145.160 MHz (with inputs at 144.500 to 144.560 MHz). Arizona had existing duplex pairs for digital operation (conventional AX.25 packet radio) in this range that they re-farmed for D-Star operation. They chose the channel spacing of 10 kHz, so these pairs are not going to be usable for APCO Project 25 repeaters, which require at least 12.5-kHz spacing. There is not much solid technical data available concerning the emission characteristics of D-Star, but most repeater groups working with the technology are adopting a min-

NFCC Asks FCC to Treat All Repeaters as Repeaters

The membership of the National Frequency Coordinators' Council has voted to ask the FCC to treat all repeaters as repeaters, regardless of mode or transmission protocol. The following motion was adopted:

That the NFCC send a letter to the FCC that states that the NFCC believes that any amateur station, other than a message forwarding system, that automatically retransmits a signal sent by another amateur station on a different frequency while it is being received, regardless of any delays in processing that signal or its format or content, is a repeater station within the meaning of paragraph 97.3(a)(39) of the rules of the Federal Communications Commission, and should be treated as such.

Under the NFCC's proportional voting system, 93 votes were cast in favor of the motion by 19 members, and 54 against by 11 members.

For the Council
Jay Maynard, K5ZC
President

imum channel spacing of 10 kHz. (Some of ICOM's marketing literature speaks of a 6.25-kHz bandwidth for D-Star emissions, but I have not found anyone whobelieves the channel spacing can be this tight.)

In Colorado, the Colorado Council of Amateur Radio Clubs (CCARC) adopted a proposal for the 70-cm and 23-cm bands but has not adopted any changes to the 2-meter band. (*Disclosure:* I chaired the committee that made these recommendations.) The CCARC adopted a 12.5-kHz channel spacing for digital voice to remain agnostic between D-Star systems and other competing standards such as APCO Project 25. The organization concluded that adopting 10-kHz channel spacing for a segment of the band would effectively make these "D-Star only" channels, something they wanted to avoid. The 12.5-kHz channel spacing is accomplished on 70 cm and 23 cm by splitting the existing 25-kHz channels into two narrow-band digital channels. On 70 cm, the CCARC created a narrow-band digital subband, 446.800 MHz to 447.000 MHz. Colorado has the repeater transmit frequency on the high side, so the repeater receiver frequency is 441.800 to 442.000 MHz for these pairs. This portion of the band was previously used for repeater linking (auxiliary operation) but is lightly used. On the 23-cm band the Colorado group adopted a flexible approach of allowing a mix of 12.5-kHz digital channels and 25-kHz analog channels (at the frequency coordinator's option). Of course, there are very few repeaters in the state on 23 cm, so currently this is not really a coordinating challenge.

The Florida Repeater Council followed an approach similar to Colorado, leaving the 2-meter band alone for now and

The K5TIT rack of D-Star gear includes (in order, starting near the top of the rack) a D-Star repeater controller, 1.2-GHz voice repeater, 1.2-GHz data radio, 146-MHz voice repeater, and 446-MHz voice repeater. (Photo courtesy of Jim McClellan, N5MIJ)

adopting 12.5-kHz narrow-band digital channels on 70 cm and 23 cm.

The Southeastern Repeater Association (SERA) is studying the band-planning issues concerning digital voice repeaters and has not yet decided on a change to its band plan. The Illinois Repeater Association has a proposal on how to support migration to digital channels on its website (drafted by Robert Shepard, KA9FLX).

The Texas VHF-FM Society has adopted a *temporary* plan to accommodate digital voice repeaters in densely populated areas. On 2 meters they reassigned some simplex frequencies to be used for digital voice repeaters: 146.450, 146.460, 146.470, 146.480, and 146.49 MHz as repeater outputs, with the repeater input 1 MHz above (147.450, 147.460, 147.470, 147.480, and 147.490 MHz). The Texas band plan already had narrow-band digital channels designated on the 70-cm band, with repeater outputs at 440.525–440.725 MHz and inputs at 445.525–445.725 MHz.

One of the more controversial changes comes from the Two-Meter Area Spectrum Management Association (TASMA) in southern California. Using the "D-Star is a form of auxiliary operation" interpretation, TASMA has designated four D-Star frequency pairs in the 2-meter band. The not-a-repeater output frequencies are 145.585, 145.595, 145.605, and 145.615 MHz, with inputs 600 kHz below at 144.985, 144.995, 145.005, and 145.015 MHz. The outputs are in the "miscellaneous and experimental modes" section per the ARRL band plan. The inputs fall into a section that the ARRL lists as *Weak signal and FM simplex.* In many parts of the country, these frequencies are used for AX.25 packet operation.

As you can see, there is not a consistent approach to allocating narrow-band digital voice repeater pairs across the U.S. Just like existing band plans, the local coordinating bodies have their own approach to assigning frequencies.

Repeater Usage

Let's take a step back from the detailed arguments around Part 97 and examine the situation with a broader view. The fundamental issue is how do we make room for new technologies when they become available. The next question is how effectively are we using the frequency spectrum today. This is the sticky question that we sometimes don't really want to ask. Program your 2 -meter rig to scan across the FM portion of the band and check the level of activity. In most areas of the country it is very quiet. There are many very capable repeater systems, but no one is talking on them. At the same time, more requests are coming in from new groups that want to put a repeater on the air.

Some hams suggest that we must free up some of the "old technology" repeater pairs to make room for newer technologies. An attractive target is to reassign pairs that are not actually being used. These so-called "paper repeaters" are coordinated but (for whatever reason) are not on the air. Most coordinating bodies allow a reasonable time to deal with equipment failures and other unexpected events that can take down a system. At some point, if the repeater isn't really operational the coordination should be pulled.

The much tougher move is to take some of those "under-utilized" repeaters off the air. If no one is talking on them, how hard can it be to shut them down? This is the proverbial can of worms, since it takes us into the business of judging the value of a repeater and how it is used. Is an ARES/RACES repeater that sits idle most of the time and becomes active mostly at net time a good use of spectrum? How do you compare that to the machine that

has "Joe and Charlie" rag-chewing on it all day? Is the actual transmit time on a repeater a good measure of its utility? Or maybe a repeater should be judged by the number of users that support it (and how do you reliably measure that?). There are lots of questions but few answers.

This is a slippery slope that frequency-coordinating bodies don't want to traverse. The reality seems to be that a functioning repeater that is consistently on the air and meeting technical standards will keep its coordination. The end result is that the old technology remains entrenched and the newer technology has to work to find a home in the spectrum. The irony is that adopting narrow-band technology such as D-Star can increase the number of available channels, opening up more repeater and simplex space. The challenge is getting there.

Beyond 2 Meters

Two meters seems to be the band everyone wants to be on, perhaps for good reason. The signals tend to propagate quite well, penetrating buildings reasonably well and diffracting around corners, too. The wavelength makes the physical size of antennas convenient. Quarter-wave verticals can be mounted on the roof of a car and still be garage compatible. High-gain Yagis can be built with 12-foot booms and lightweight masts. FM transceivers are amazingly affordable for the band, with 50-watt, fully-synthesized rigs with all the bells and whistles priced at less than $150. There is much to like about 2 meters.

On the other hand, we might be better off looking beyond 2 meters, especially for the early deployment of D-Star systems. In most areas of the country, a slice of the 70-cm band can be carved out for digital voice usage. Most of the hams interested in D-Star are in the *early adopter* category. These are the guys who are the first ones on the block to try out something. Price is not usually their primary concern. (If it was, they would be holding fast to their existing 2-meter FM rigs.)

Recommendations

I've tried to represent the situation in a balanced way, including conflicting points of view from many sides. I do have some specific recommendations to share. These do not represent the position of *CQ VHF* or anyone else.

• Work with your local frequency coordinating body to develop a plan that works in your area. The last thing we should do with D-Star (or any other new technology) is deploy it randomly across the VHF/UHF bands.

• Consider deploying new technology such as D-Star on one of the less used bands (i.e., not 2 meters).

• If you or your group has a repeater that is off the air, either get it fixed or return the frequency pair for reassignment.

• If you or your repeater group operates one of those lightly used repeaters, consider whether that is a good use of that frequency spectrum. What is the purpose of that repeater and why is it lightly used?

• Consider whether you or your repeater group could lead the way on adopting narrow-band digital technology by converting an analog pair over to narrow-band digital.

These are my thoughts. Please let me know what ideas you have.

Tnx and 73

Thanks for taking the time to read another one of my columns on the "utility mode." I always enjoy hearing from readers, so drop me an e-mail at <bob@k0nr.com> or stop by my blog at <http://www.k0nr.com/blog>.

73, Bob KØNR

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Southeastern Repeater Assn.: <http:// www.sera.org>.

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Texas VHF-FM Society: <http://www. txvhffm.org>.

Two-Meter Area Spectrum Management Association: <http://www.tasma.org>.

ALABAMA D★STAR

D-STAR in the Southeastern U.S.

In the aftermath of Hurricane Katrina, the need for reliable VHF-plus communications was made painfully clear. W4OZK discusses why and how D-STAR is being used throughout Alabama to fill that need and how Alabama's network can be used as a model for the rest of the country.

By Greg Sarratt,* W4OZK

What is this D-STAR technology that everyone is talking about? D-STAR stands for Digital Smart Technology for Amateur Radio. Developed in Japan, D-STAR is now accepted and growing like wildfire in the United States. In a nut shell, D-STAR is a three band, fully digital repeater system that can pass digital voice and digital data.

A nationwide network of 52 D-STAR systems exists, enabling amateurs to make a connection with one another, whether locally or in another city via the internet. These networked systems are not dependent on one another, so if any single or several systems go down, the rest of the network continues to work.

D-STAR's Pioneering Growth

Pioneering this D-STAR technology is the southeastern U.S., and Alabama leads the charge. In 2001 a couple of Alabama hams started investigating an previously unknown technology called D-STAR, developed a plan, and began implementing this new digital technology. In 2006–2007 Alabama has advanced this technology with nationwide training, seminars, users meetings, and 12 operational systems throughout the state.

The 12 Alabama digital repeater systems include over 31 digital repeaters and 10 high-speed data modules. In addition, there are more systems on the drawing board. A variety of individual clubs,

Figure 1. The Alabama Emergency Management Agency districts are in red, the active D-STAR system installations are in the blue boxes, and systems that are in the works are depicted by the black towers.

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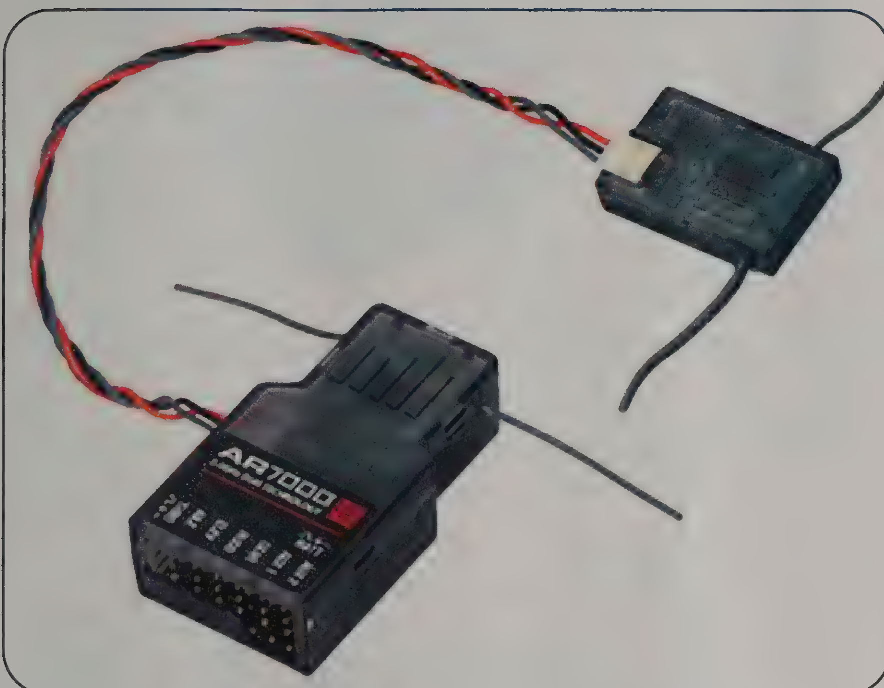
By Del Schier,* K1UHF

AIRBORNE RADIO

Using Amateur Radio to Control Model Aircraft

Radio Control QSYs to 2.4 GHz



Spektrum 2.4-GHz dual-diversity receiver. Note the tiny dipole wires out of each receiver module.

Futaba transmitter module that converts a Futaba VHF transmitter to 2.4 GHz.

Almost since the beginning of radio control, hams used 50 MHz for RC and it is still used to this day. However, all good things must come to an end. When I started writing this column, I knew that RC radio manufacturers were about to introduce 2.4-GHz spread-spectrum transmitters and receivers, but flying a RC airplane on 6 meters was still the way to go.

The primary advantage of being both a ham and an RC modeler was that you could fly on 50 MHz. The advantage is there is a much lower chance of a channel conflict than on the unlicensed 72-MHz RC band, and of course, it is a huge concern that you have a clear channel to fly RC aircraft; otherwise there are obvious problems.

In a very short time, 2.4-GHz spread-spectrum (SS) RC radios have become available from most of the major manufacturers and a few new, smaller ones. The use of unchannelized spread spectrum allows many radios to operate at the same flying field with no noticeable interference and or worry about channels.

It is interesting that in 1898 Nikola Tesla actually recognized the advantage of a secure spread-spectrum system for radio control and filed a patent for it. Basically, spread spectrum uses a much wider bandwidth than is needed to transmit the necessary information and relies on a unique synchronized and coded protocol of modulation and frequency hopping, so the receiver only recognizes "its" transmitter. SS has to be synchronized, or married, in order for communication to take place. It is possible that two systems could interfere, but that is very unlikely, as even the simple SS system in a cordless phone would have thousands of unique combinations. The recent availability of inexpensive SS systems for RC model airplanes is probably a direct result of the mass-marketed technology used in cordless phones and WiFi Ethernet.

The features and functions of 2.4-GHz RC equipment are basically the same as VHF equipment, except that the antennas are smaller and easier to deal with. The transmitter can be your older VHF transmitter with a new 2.4-GHz transmitter module plugged in the back, or you can

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A Spektrum-brand transmitter module available for JR or Futaba transmitters.

Spektrum single receiver without dual diversity for close-range flying.

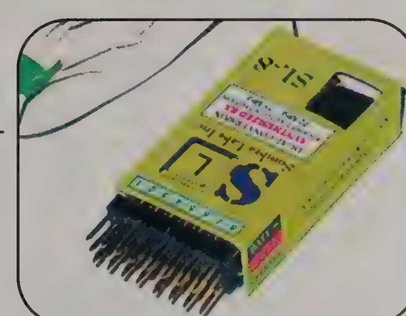
Module-equipped JR transmitters available for 2.4 GHz, 50 MHz, or 72 MHz.

purchase a complete, new dedicated 2.4-GHz SS transmitter.

There is some question as to whether 2.4-GHz SS has the range of the older VHF systems, but so far the performance looks good, with very few problems reported. The manufacturers are using exotic techniques such as dual-diversity reception. You be sure they would not have done that if they were not already on the edge of having range issues.

The advantage of this new equipment is the promise of no interference and no worry about channels, and the antennas are smaller and easier to deal with. The disadvantage is that they are more expen-

A new Futaba transmitter with 2.4 GHz built in.



The new 50-MHz Sombra Synthesized DSP receiver.

sive than VHF equipment and there is less to choose from, but this surely is a temporary issue.

The manufacturers seem to be discontinuing VHF RC equipment, especially on 6 meters. However, there is one company, Sombra Labs (its products carried by West Mountain Radio), that just came out with a new state-of-the-art, fully synthesized 6-meter RC transmitter. Consider that you may not be able to get 6-meter equipment much longer. I would love to switch over to 2.4-GHz SS, but it would cost me a fortune to re-equip my over 30 airplanes, not to mention the time it would take to do that with reprogramming and retest flying them.

Even though 2.4 GHz is a ham band, there is no license required. It pretty much looks like 6-meter and 72-MHz RC radios will be extinct very soon as technology changes within our hobbies.

I have enjoyed writing this column and I hope you have enjoyed reading it, but I have decided that this will be last one. I hope that I have pretty much covered everything I wanted to and have given my fellow hams a good insight into RC modeling, a great companion hobby to amateur radio. Happy flying!

73, Del, K1UHF

Links

http://www.futaba-rc.com
http://www.jrradios.com
http://www.sombralabs.com
http://www.spektrumrc.com
http:/www.westmountainradio.com

By Tomas Hood,* NW7US

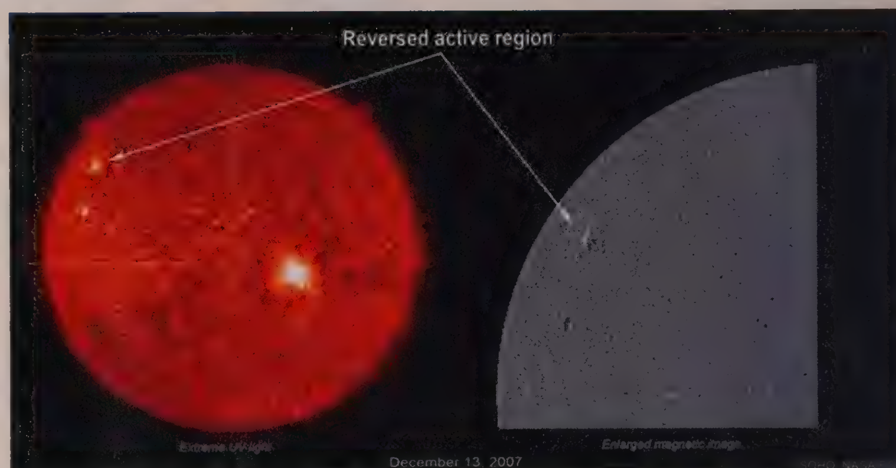
PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The New Solar Cycle Has Begun!

January 4, 2008 was a pretty exciting day for solar scientists, as well as amateur radio operators. When observers took a close look at the day's images of the sun, they noticed that a small sunspot had developed with a much-anticipated feature—a reversed magnetic polarity. Such a reversal marks the start of the new solar cycle, the 24th recorded cycle.

The excitement actually started in December, when a magnetically reversed, highly active region appeared in the sun's eastern limb. Because of its reversed polarity, scientists became hopeful that the region would develop into an actual sunspot. If it had, then scientists would have declared the official start of Cycle 24.



This UV-wavelength image of the sun (left) and a map showing positive (white) and negative (black) magnetic polarities (right) illustrate an active region that sparked a lot of excitement in December 2007. The new high-latitude active region was magnetically reversed, marking it as a harbinger of a new solar cycle. If the active region turned into an actual sunspot, scientists would have declared the start of solar Cycle 24 during December. However, a sunspot group never developed with a reversed polarity during December. (Source: SOHO/NASA)

Sunspots have a complex magnetic structure. Typically, though, a sunspot will have at least one very clearly defined set of magnetic poles, north and south. At the start of a new solar cycle, the polarities of the new cycle's sunspots are reversed from the polarities observed in sunspots belonging to the previous cycle. When the first sunspot arrives with a reversed magnetic structure, scientists declare the start of the new cycle. This occurred on January 4, 2008.

What is in store for 2008? Solar cycles take anywhere from two to five years to reach the point of maximum solar activity. The current consensus among most solar scientists places Cycle 24's maximum sometime between 2011 and 2013. That means we have at least a year or two before we see major solar activity of the kind useful to VHF propagation. However, that does not mean that 2008 will be a disappointment for VHF DXers.

Space Weather and VHF Propagation

Since the sun's magnetic field permeates the entire solar system and beyond (in a region called the *heliosphere*), it interacts with the Earth's magnetic field (a field known as the *magnetosphere*). The sun's huge magnetic field is called the *Interplanetary Magnetic Field* (IMF) and is a primary cause of space weather. Sprawling out away from the sun is a solar wind that rides the IMF.

As Earth orbits the sun, it dips in and out of the wavy current sheet of the IMF, known as the *Parker Spiral*. On one side the sun's magnetic field it points north, or toward the sun. On the other side it points south, or away from the sun. The IMF's orientation is indicated by the "B_z" index. When the B_z is negative, it indicates a southerly orientated IMF; when iy is positive, it indicates a northerly oriented IMF.

South-pointing solar magnetic fields tend to "magnetically reconnect" with Earth's own magnetic field. This allows the solar wind, and the solar plasma that is riding the solar wind out away from the sun, to flow in and collect in a reservoir known as the *boundary layer*. The energetic particles riding the solar wind can then penetrate the atmosphere and trigger geomagnetic storms, as well as aurora.

If the IMF is oriented northward, however, this magnetic reconnection does not take place. This instead creates a barrier against the solar wind and the plasma riding the IMF.

Solar plasma originates from a number of solar features, including coronal holes, coronal mass ejections (CMEs), and coronal jets. Coronal holes are regions in the sun's corona (an atmospheric layer of the sun that could be thought of as one of Earth's atmospheric layers, like the stratosphere) where the corona is darker than the surrounding area. These features were discovered when X-ray telescopes were first flown above the Earth's atmosphere to reveal the structure of the corona across the solar disc. Coronal holes are associated with "open" magnetic-field lines and are often found at the sun's poles. A coronal hole simply means an area where a breakdown in the magnetic fields in the solar corona has occurred. Often high-speed solar wind is known to originate in coronal holes. This escape of solar plasma and energy streams outward away from the sun into the solar wind. It

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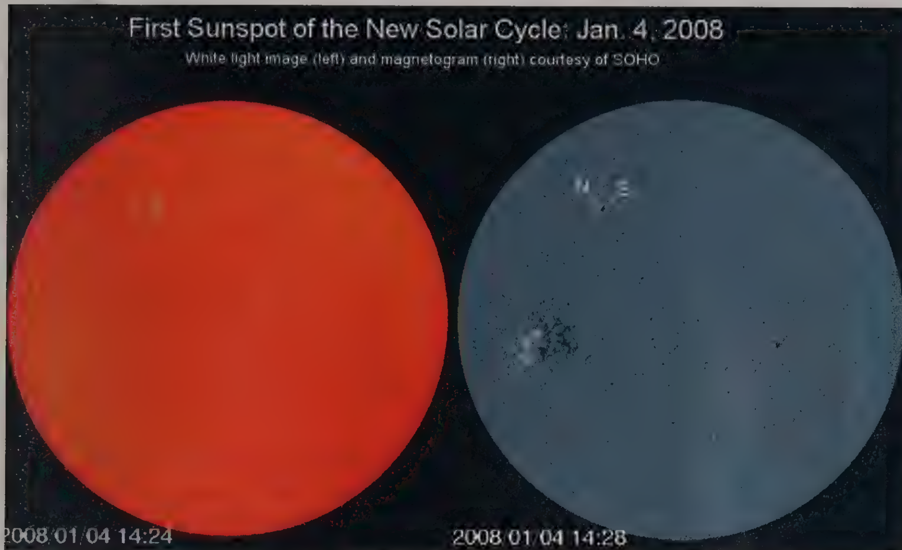

On January 4, 2008 a magnetically reversed sunspot emerged at solar latitude 30 north. This marked the start of solar Cycle 24. The sunspot, numbered 981, is the first to appear with a reversed magnetic polarity. The reversal is in relation to the polarity found in the sunspots occuring during Cycle 23. (Source: NASA/SOHO)

is the existence of coronal holes that will play a significant role in 2008's Spring Equinoctial season.

Winter 2008

Each year we have two seasons when significant space weather has a greater influence in causing geomagnetic disturbances: The first is known as the Spring Equinoctial season; the second is known as the Autumnal Equinoctial season. The Spring Equinoctial season peaks between March and April of each year; during this year's equinoctial season, there is moderate chance of geomagnetic activity combined with space weather to trigger small to medium aurora events.

Known as the Vernal Equinox, March 20, 2008 at 0548 UTC, the hours of daylight and darkness are about equal around the world. It is well-documented that this is one of the two optimal times of the year for aurora. Geomagnetic storms that ignite auroras occur more often during the months around the equinoxes during early autumn and spring. This seasonal effect has been observed for more than 100 years.

These two seasonal peaks in yearly auroral activity occur because the Earth's magnetic dipole axis is most closely aligned with the Parker Spiral in April and October. As a result, southward (and northward) excursions of B_z are greatest then. This is why aurora is most likely and strongest during the equinoctial months. When you see the solar wind speed increase to over 500 kilometers per second, and the B_z remains mostly negative (the IMF is oriented mostly southward), expect an increase in geomagnetic activity, as revealed by the planetary *K*-index (*Kp*).

What is Aurora?

Aurora is a direct result of solar plasma interacting with gasses in the upper atmosphere. It is common to see aurora during active to severe geomagnetic storms. The magnetosphere is filled with electrons and protons that normally are trapped by lines of magnetic force that prevent them from escaping to space or descending to the planet below. The influence of solar wind that has been enhanced by coronal holes can cause some of those trapped particles to break loose, causing them to rain down on the atmosphere. Gasses in the atmosphere start to glow under the impact of these particles. Different gasses give out various colors. Think of a neon sign and how the plasma inside the glass tube, when excited, glows with a bright color. These precipitating particles mostly follow the magnetic-field lines that run from Earth's magnetic poles and are concentrated in circular regions around the magnetic poles, and are called *auroral ovals.* These bands expand away from the poles during magnetic storms. The stronger the storm, the more these ovals will expand. Sometimes they grow so large that people at middle latitudes, such as in California, can see these "Northern Lights."

When you see the solar wind speed increase to over 500 kilometers per second, and the B_z remains mostly negative (when the Interplanetary Magnetic Flux is oriented mostly southward), expect an increase in geomagnetic activity, as revealed by the planetary *K*-index (*Kp*).

When the *Kp* rises above 4, look for aurora-mode propagation. The higher the *Kp*-index, and the longer the geomagnetic storminess lasts, the more likely we'll have strong aurora openings. You don't have to see them to hear their influence on propagation. Listen for stations from over the poles that sound raspy or fluttery. Look for VHF DX. Sometimes it will enhance a path at certain frequencies, while other times it will degrade the signals. Sometimes signals will fade quickly and then come back with great strength. The reason for this is the radio signal is being refracted off the more highly ionized areas that are lit up. These ionized areas ebb and flow, so there is the ability to refract changes, sometimes quickly. I've observed the effect of aurora and associated geomagnetic storminess even on lower HF frequencies.

Radio Aurora

If there are enough solar particles flowing down the Earth's magnetic-field lines and colliding with atmospheric atoms and molecules, ionization occurs. This ionization may be sufficient to reflect VHF and lower UHF radio waves, generally between 25 and 500 MHz. This usually occurs in conjunction with visual aurora, but the mechanism is a bit different and it is possible to have one (visual or radio) without the other.

Using radio aurora, the chances of contacting stations over greater distances than would ordinarily be possible on the VHF frequencies is increased. Like its visual counterpart, radio aurora is very unpredictable. The thrill of the chase draws many VHF weak-signal DXers to working auroral DX.

VHF auroral echoes, or reflections, are most effective when the angle of incidence of the signal from the transmitter, with the geomagnetic field line, equals the angle of reflection from the field line to the receiver. Radio aurora is observed almost exclusively in a sector centered on magnetic north. The strength of signals reflected from the aurora is dependent on the wavelength when equivalent power levels are employed. Six-meter reflections can be expected to be much stronger than 2-meter reflections for the same transmitter output power. The polarization of the reflected signals is nearly the same as that of the transmitted signal.

The *K*-index is a good indicator of the expansion of the auroral oval, and the possible intensity of the aurora. When the *K*-index is higher than 5, most hams in the northern states and in Canada can expect favorable aurora conditions. If the *K*-index reaches 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and Florida. Your magnetic latitude can be found using the map at <http://www.sec.noaa.gov/Aurora/globeNW.html>.

The Solar Cycle Pulse

The observed sunspot numbers from October through December 2007 are 0.9, 1.7, and 10.1. (A correction to the numbers reported in the last issue: July through September observed sunspot numbers are 10.0, 6.2, and 2.4). The smoothed sunspot counts for April through June 2007 are 9.9, 8.7, and 7.7.

The monthly 10.7-cm (preliminary) numbers from October through December 2007 are 65.5, 69.7, and 78.6. The smoothed 10.7-cm radio flux numbers for April through June 2007 are 75.2, 74.2, and 73.2.

The smoothed planetary *A*-index (*Ap*) numbers from April through June 2007 are 8.5, 8.4, and 7.8. The monthly readings from through December 2007 are 9, 5, and 4.

The smoothed monthly sunspot numbers forecast for January through March 2008 are 4, 3, and 3, while the smoothed monthly 10.7-cm is predicted to be 62, 62, and 61 for the same period.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-E, meteor scatter?). I'll create summaries and share them with the readership. You are also welcome to share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center, <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing. 73 de Tomas, NW7US

Cycle 24 Begins!

Has sunspot Cycle 24 finally begun? Here KH6/K6MIO follows up on his article in the Fall 2007 issue of *CQ VHF* with a report on what seems to be the positive indicator that the new cycle has begun.

By Jim Kennedy,* KH6/K6MIO

Six-meter devotees have anxiously been awaiting the peak years of solar Cycle 24 and the return of good ionospheric DX conditions. In December 2007 and January 2008 we saw the first solid indications that Cycle 24 is beginning to rev up.

At the end of one cycle and the beginning of the next cycle, there is a period of time when the two cycles overlap. Magnetically active regions and associated sunspots from both cycles are seen on the sun at the same time.

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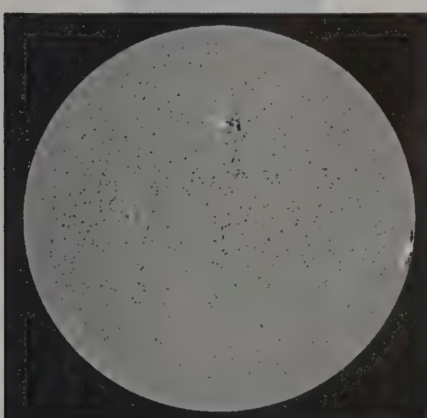
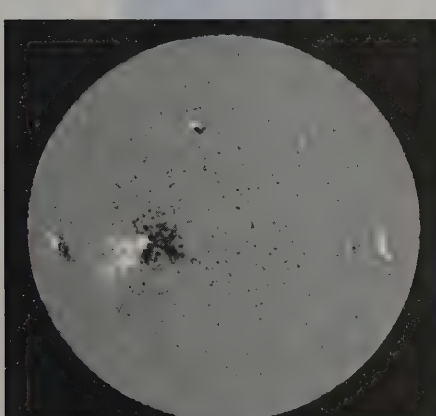


An NSO solar magnetogram from December 18, 2007 shows the magnetic pair 30N-145. Note its position in the dateline in figure 1. (Credit: NSO/AURA/NSF)



An NSO solar magnetogram from January 5, 2008 shows the magnetic pair 30N-250. Note its position in the dateline in figure 1, along with much larger 10S-240 and smaller 10N-330 groups from Cycle 23. (Credit: NSO/AURA/NSF)

Sunspots always appear as pairs in active regions. Powerful dipolar magnetic fields connect the leading and following spot in each pair, giving the pair a characteristic magnetic polarity. In one of the sun's (north/south) hemispheres, the field will point outward from the leading spot and inward to the following spot, and in the other hemisphere it will be *exactly the opposite*—inward to the leading spot and outward from the following spot.

These characteristics make it possible to readily tell the difference between the old-cycle and new-cycle regions:

1. Old-cycle spots are *near the equator,* with their spot-pair polarities opposite in the Northern and Southern Hemispheres.
2. New-cycle spots are *near 30°* north and south latitudes, with *north and south polarities that are reversed* from that of old-cycle pairs.

The beginning of each new cycle is indicated by the sustained appearance of these *30° latitude, reversed-polarity* magnetic active regions, often with spot pairs or groups.

There was a brief appearance of a small reversed-polarity spot pair near 30° south in July 2006, but it vanished almost immediately. It was a fluke; nothing further was seen for 17 months.

That changed on December 11, 2007, when an already-formed reversed-polarity active region pair rotated over the limb into view. While no actual sunspots formed, the magnetic structure was clear. The system grew in size for a few days and then began to diminish and rotated out of view on the 23rd. Then, on January 2, 2008, another reversed-polarity magnetic region (981) emerged and produced a small sunspot group. This was a second, distinct region and *not* a recurrence of the December group (see figure 1).

Since Northern Hemisphere activity has preceded that of the Southern Hemisphere for the last few cycles, and now two reversed-polarity northern groups have been seen, this is a good indication that Cycle 24 is finally arriving.

At this writing (early January), the R_i sunspot index has been very low (<12) since June 2007. It appears that solar minimum is very near, but may not have occurred yet. This would seem to eliminate all but three of the professional Cycle 24 predictions discussed in my previous article[1], as the others called for much earlier minimum dates.

Two of the remaining predictions are those from the strongly-split NOAA panel. While both factions on the panel predicted that minimum would occur in March 2008 plus or minus six months, one group predicted a very weak maximum (R_i max approximately 90), and the other predicted one stronger than Cycle 23 (R_i max approximately 140). The panel will review its findings in March 2008.

The third remaining prediction is that made by Mausumi Dikpati and her collaborators at the High Altitude Observatory, which calls for (R_i max approximately 169), and a minimum in late 2007 or early 2008. Only time will tell.

(For more information on the start of Cycle 24, see NW7US's "VHF propagation" column in this issue of CQ VHF.*)*

Note

1. Kennedy, Jim, KH6/K6MIO, "Solar Cycles and Cycle 24 Predictions," Fall 2007 *CQ VHF*, pp. 10–19.

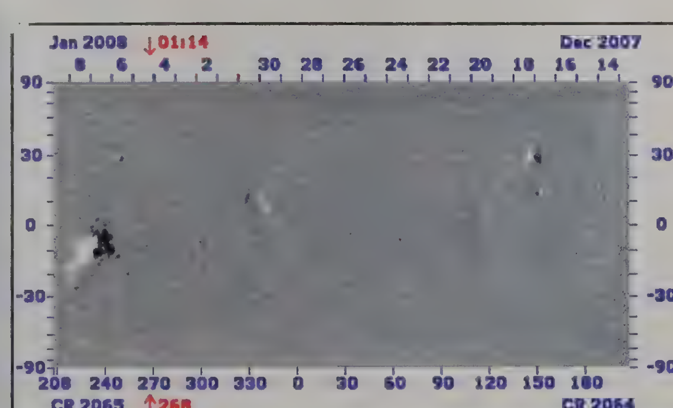


Figure 1. This Global Oscillation Network Group (GONG) magnetogram is a latitude-longitude map of the surface fields of the whole Sun from December 14, 2007 to January 8, 2008. The magnetic pairs at 30N-145 and 30N-250 are the December and January Cycle 24 regions, respectively. The large group at 10S-240 and the small group at 10N-330 are Cycle 23 regions. Note that the white/black polarity sense of the 30N Cycle 24 regions is the opposite of the 10N Cycle 23 region. (Credit: GONG/NSO/AURA/NSF)

QUARTERLY CALENDAR OF EVENTS

Current Contests

The European Worldwide EME Contest 2008: Sponsored by DUBUS and REF, the EU WW EME contest is intended to encourage worldwide activity on moonbounce. Information on this contest was not available at press time. Please check with N6CL's "VHF Plus" column in *CQ* magazine for a future announcement.

Spring Sprints: These short-duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. Please check with the "VHF Plus" column in *CQ* magazine for a future announcement.

The **2 GHz and Up World Wide Club Contest:** Sponsored by the San Bernardino Microwave Society, this contest runs in early May. Rules are available at the following URL: <http://www.ham-radio.com/sbms>.

Conference and Convention

Southeast VHF Society: The 12th annual conference will be hosted in Atlanta, Georgia, April 25 and 26, 2008 at the Holiday Inn/UCF, 12125 High Tech Ave., Orlando, FL (phone 407-275-9000). For information on registering for the conference, please check the society's website at <http://www.svhfs.org/>.

Dayton Hamention®: The Dayton Hamvention® will be held as usual at the Hara Arena in Dayton, Ohio, May 16–18, 2008. For more information, please see the website: <http://www.hamvention.org>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, e-mail, etc., please contact the person listed with the announcement. The following organization or conference organizer has announced a call for papers for its forthcoming conference:

The **Southeast VHF Society** (see conference dates announcement above): The deadline for the submission of papers and presentations is February 29, 2008. All submissions should be in Microsoft Word (.doc) or alternatively Adobe Acrobat (.pdf) files. Pages should be 8 1/2 by 11 inches with a 1-inch margin on the bottom and 3/4-inch margin on the other three sides. All text, drawings, photos, etc., must be black and white only (no color). Please indicate when you submit your paper or presentation if you plan to attend the conference and present there or if you are submitting just for publication. Papers and presentations will be published in bound *Proceedings* by the ARRL. Send all questions, comments, and submissions to the technical program chair, Steve Kostro, N2CEI, at <svhfs2008@downeastmicrowave.com>. For further information about the conference go to <http://www.svhfs.org>.

The **Central States VHF Society Conference**: Technical papers are solicited for the 42nd annual Central States VHF Society Conference to be held in Wichita, Kansas on July 24–27, 2008. Papers, presentations, and posters on all aspects of weak-signal VHF and above amateur radio are requested. You do not need to attend the conference, nor present your paper, to have it published in the *Proceedings*. Posters will be displayed during the two days of the conference.

Non-weak signal topics, such as FM, repeaters, packet radio, etc., generally are not considered acceptable. However, there are always exceptions. Please contact the folks below if you have any questions about the suitability of a topic. Strong editorial preference will be given to those papers that are written and formatted specifically for publication, rather than as visual presentation aids.

Deadline for submissions: For the *Proceedings* June 2; for presentations delivered at the conference June 30; and for notifying them that you will have a poster to be displayed at the conference also June 30. Please bring your poster with you on July 25,. Contact information: Mel Graves, WRØI, via e-mail: <wr0i@sgdrugfree.com>, or snail mail at: Melvin Graves, WRØI, P.O. Box 273, Wichita, KS 67201-0273.

Submissions can be made via the following: Electronic formats (preferred); via e-mail; uploaded to a website for subsequent downloading; on media (3.5-inch floppy, CD, USB stick/thumb drive).

Meteor Showers

The *α-Centaurids* meteor shower is expected to peak on February 8 at 1700 UTC. The *γ-Normids* shower is expected to peak on March 13. Other February and March minor showers include the following and their possible radio peaks: *Capricornids/Sagittarids,* February 2, 0300 UTC; and *χ-Capricornids,* February 14, 0400 UTC.

The *Lyrids* meteor shower is active during April 16–25. It is predicted to peak around 0500 UTC on 22 April. This is a north-south shower, producing at its peak around 10–15 meteors per hour, with the possibility of upwards of 90 per hour.

A minor shower and its predicted peak is *pi-Puppids* (peak on April 23, at 1000 UTC). Other April, May, and June minor showers include the following and their possible radio peaks: April *Piscids,* April 20, 0300 UTC; *δ-Piscids*, April 24, 0300 UTC; *η-Aquarids*, May 5, 1800 UTC; *ε-Arietids*, May 9, 2000 UTC; May *Arietids,* May 16, 0300 UTC; and *o-Cetids,* May 20, 0100 UTC. June *Arietids,* June 7, 0500 UTC; *zeta-Perseids,* June 9, 0400 UTC; and *β-Taurids*, June 28, 0400 UTC.

For more information on the above meteor shower predictions please visit the International Meteor Organization's website: <http://www.imo.net>.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

Feb. 3	Very poor EME conditions
Feb. 7	New Moon
Feb. 10	Good EME conditions
Feb. 14	First Quarter Moon and Moon Perigee
Feb. 17	Moderate EME conditons
Feb. 21	Full Moon and Total Lunar Eclipse visible throughout most of the Americas, Africa, and Europe
Feb. 24	Moderate EME conditions
Feb. 28	Moon Apogee
Feb. 29	Last Quarter Moon
March 2	Very poor EME conditions
Mar. 7	New Moon
Mar. 9	Good EME conditions.
Mar. 10	Moon Perigee
Mar. 14	First Quarter Moon
Mar. 16	Moderate EME conditions
Mar. 20	Spring Equinox
Mar. 21	Full Moon
Mar. 23	Moderate EME conditions
Mar. 26	Moon Apogee
Mar. 29	Last Quarter Moon
Mar. 30	Very poor EME conditions.
Apr. 6	New Moon; Good EME conditions
Apr. 7	Moon Perigee
Apr. 12	First Quarter Moon
Apr. 13	Good EME conditions
Apr. 20	Full Moon; Poor EME conditions
Apr. 22	*Lyrids* Meteor Shower Peak
Apr. 23	Moon Apogee
Apr. 27	Very poor EME conditions
Apr. 28	Last Quarter Moon
May 4	Good EME conditions.
May 5	*Eta Aquarids* Meteor Shower Peak and New Moon
May 6	Moon Perigee
May 11	Very good EME conditions
May 12	First Quarter Moon
May 18	Poor EME conditions
May 20	Full Moon and Moon Apogee
May 25	Poor EME conditions
May 28	Last Quarter Moon
June 1	Good EME conditions
June 3	Moon Perigee and New Moon
June 8	Excellent EME conditions
June 10	First Quarter Moon
June 15	Poor EME conditions
June 16	Moon Apogee
June 18	Full Moon
June 21	Summer Solstice
June 22	Poor EME conditions
June 26	Last Quarter Moon
June 29	Moderate EME conditions

—EME conditions courtesy W5LUU.

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Transatlantic Balloon Race

Part of the fun and challenge of Amateur Radio High Altitude Ballooning (ARHAB) is to push the envelope towards new achievements. Ralph Wallio, WØRPK, maintains an ARHAB Flight Records page on his website (www.arhab.org) that documents some of these achievements. Each year a contest is held with categories such as Highest Altitude, Longest Flight Time, Greatest Flight Distance, Greatest Telemetry Reception Range (VHF/ UHF), Greatest Telemetry Reception Range (HF), and Greatest Two-Way QSO via balloon transponder or repeater.

Several balloon groups have been pushing towards the ultimate goal of having a balloon repeater/transponder that flies for several days at high altitude. Imagine having the equivalent of an AMSAT satellite that floats slowly across the U.S. (or around the world) for hours or days. The great advantage of a BalloonSat is that due to its slow speed relative to an AMSAT bird and its closer proximity to Earth, anyone with a modest amateur radio station can easily work through the balloon relay without worrying about slinging antennas rapidly across the sky, and much lower power is necessary to make a contact. Some of the two-way QSOs that were made via a VHF/UHF balloon repeater have been over 700 miles (a 777-mile DX QSO is the record so far, set by N8DEZ/6 and N5QO via the ANSR balloon relay from Phoenix, Arizona).

*12536 T 77, Findlay, OH 45840
e-mail: <wb8elk@aol.com>

The Contenders

One of the ultimate goals, and also the toughest to achieve, has been to lob a balloon payload clear across the Atlantic Ocean. The unmanned balloon equivalent of Charles Lindbergh's transatlantic solo flight, a handful of balloon groups have taken up the challenge and the race is on!

It turns out that the best time of year to achieve a transatlantic flight is during the winter months. The jet stream can exceed

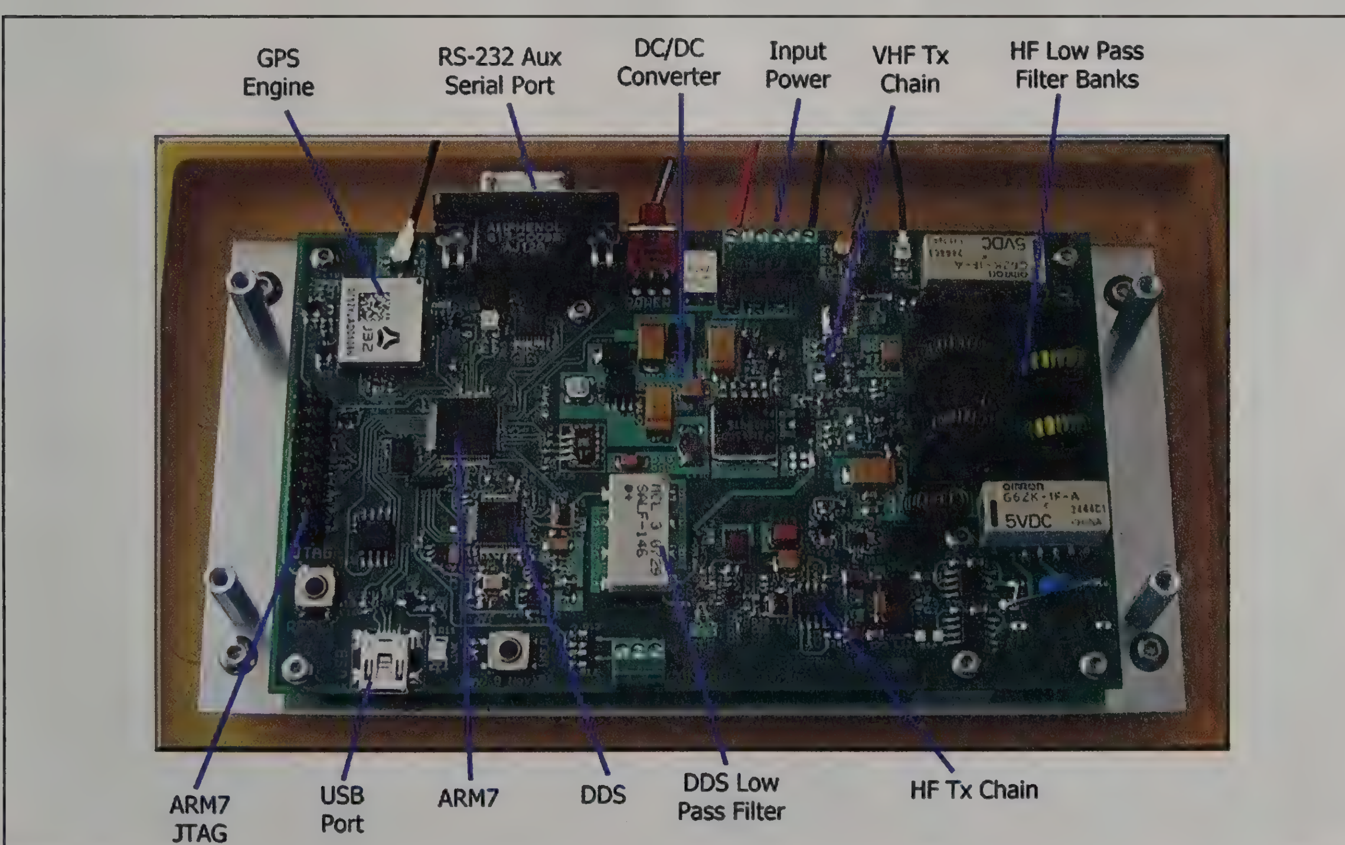


Photo 1. The HF PSK-31 and VHF APRS ANSR long-duration payload PC board. (Photo by Michael Gray, KD7LMO)

Photo 2. Robert Rochte, KC8UCH, launches his solar balloon from Grosse Pointe Academy.

Photo 3. Launch of the UTARC Spirit of Knoxville UX-19 balloon.

170 knots at this time of year, and the trend is for a flight that goes east at a high speed. Some days the winds are so strong that a balloon could make the transit in less than 48 hours.

So far four groups have thrown their hats in the ring, and there could be a few more as the competition heats up. In alphabetical order, here are the current contenders:

ANSR

The Arizona Near Space Research (ANSR) group (www.ansr.org) plans to fly a custom-built payload that includes APRS as well as PSK-31 telemetry (see photo 1). Using a circuit designed and built by Michael Gray, KD7LMO, this multi-band HF PSK-31 telemetry transmitter can be heard for thousands of miles, allowing anyone with a modest HF PSK-31 station to follow the flight's progress. (Michael's innovative circuit designs can be viewed at: <www.kd7lmo.net>.)

In addition to its extensive student experiment program using conventional latex balloons, ANSR has achieved some remarkable long-duration flights using a special plastic balloon designed and supplied by Mark Caviezel of Global Western. The group has made several multi-day flights so far, and the longest

Photo 4. WB8ELK's Hi-Ball 8 long-duration balloon launch (left to right): Barry, N4MSJ; Thad, WB4VHF; Jason, KG4WSV; Gary, N4TXI; and Jim WA8VWY.

mission has been 775 miles downrange. If ANSR makes it across the Atlantic, it will indeed be quite an achievement, since the group has the disadvantage of having to trek across most of the continental U.S. before reaching the Atlantic seaboard.

Grosse Pointe Academy

Robert Rochte, KC8UCH, has been researching and building unique experimental balloon designs and has achieved amazing results using super-pressure balloons made out of mylar, as well as solar balloons that require no helium (see photo 2). Many of his solar balloons have carried APRS transmitters up to over 65,000 feet, and they have floated there all day long until the sun went down. He's had many flights of several hundred miles, and his farthest was a landing in New Brunswick, Canada, 933 miles. His longest duration flight so far was a super-pressure design that stayed up 32 hours carrying a 5-ounce APRS payload. Robert is Director of Technology at Grosse Pointe Academy in the Detroit, Michigan area and involves his students in the entire process (see <http://mail.gpacademy.org/~rochter/default.htm>). The students build the balloon in the classroom as well participate in the launch, data collection, and tracking of the mission. This is a wonderful hands-on way of teaching science and engineering in a way that few students get to experience. Robert has a ballooning blog at the following address: (http://arhab.blogspot.com/).

UTARC

Members of the University of Tennessee Amateur Radio Club (UTARC) in Knoxville, Tennessee have been actively pursuing long-duration flight with a number of innovative flights (see photo 3). Their transatlantic effort has been dubbed "The Spirit of Knoxville" (www.spiritofknoxville.com), and they maintain a unique website that links into the APRS server system as well as their own internet-linked RTTY (Radio Teletype) system to provide real-time charts of the balloon's telemetry. Their web-linked RTTY system is particularly unique in that they have developed a web-server-linked interface to the popular MMTTY program that they call DTRC (Distributed Tracking and Relay Client). It's a free RTTY decoder program and allows anyone who receives the HF RTTY signal from the balloon to automatically send what they receive directly to the UTARC team. In addition, any ham can view online what other hams have decoded on RTTY anywhere in the world. So far they have the record for farthest HF telemetry reception by DJ1YFK at over 4572 miles. Their most recent flight splashed down in the Atlantic way past the South Carolina coast after flying 589 miles. They plan to transmit on 144.39 APRS while over the US mainland, and then start transmitting standard 45-baud RTTY and CW on the 30-meter band while over the Atlantic and flying a Global Western balloon.

WB8ELK

I have longed dreamed of flying a balloon across the "pond." Over the past few years I have done a number of test flights using both plastic balloons and traditional latex balloons (see photo 4). My transatlantic effort will consist of a 30-meter and 20-meter standard RTTY and CW transmitter sending down location and altitude as well as APRS on 144.39 MHz until it's past VHF range to the shoreline. Based in the Huntsville, Alabama area, it doesn't take more than a few hours to make it out over the Atlantic if the upper altitude winds are high.

Over the years, I've dropped a dozen payloads into Davy Jones's locker. My most recent series of transatlantic test flights have dropped four payloads into the Bermuda Triangle. My farthest flight so far was 1400 miles downrange, and the balloon splashed down off the coast of Nova Scotia after flying for over 22 hours. I will also be using a Global Western balloon supplied by Mark Caviezel. Updates and flight results can be viewed on my website: (www.wb8elk.com).

Due to the wonders of HF propagation, anyone can track these flight attempts using just a free sound-card decoding program. As always, you can find out when these efforts will fly by checking out the national Amateur Radio High Altitude Balloon website, <www.arhab.org>, where most balloon flights are posted in advance.

73, Bill, WB8ELK

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Millimeter Magic

Where, exactly, within the vast electromagnetic spectrum are we most likely to detect radio evidence of our cosmic companions? The question is important to practitioners of SETI science, professional and amateur alike, because our terrestrial technology is limited. Wouldn't it be wonderful if we could view the whole spectrum, DC to daylight, in real time? We're talking about the ultimate panadaptor. However, that's a little like trying to monitor every frequency on every ham band simultaneously in order not to miss the next opening to that elusive DX station.

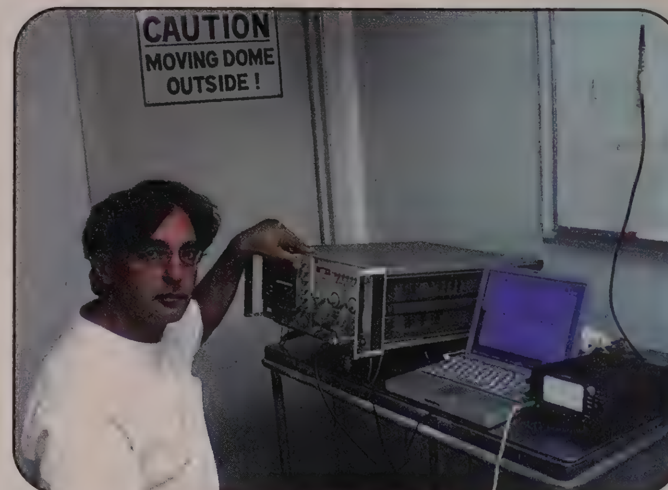
The DX that SETIzens seek, however, is even more elusive than the rarest uninhabited island which might some day be activated. At least, when a trek is mounted to a remote corner of planet Earth, we know the DXpedition's destination, what bands the team members plan to operate, what callsign they will use, their preferred modulation modes, and how long they plan to be there. With interstellar DX, we don't even know for sure that they *exist,* much less the particulars of their QTH, operating schedule, or band plan. Lacking any *a priori* knowledge, all we can do is guess, and the better we guess, the greater our chance of success.

The first scientific paper proposing modern SETI, co-authored by Prof. Phil Morrison, W8FIS, back in 1959, appeared in the prestigious British science journal *Nature.* In it, Morrison and his colleague Giuseppi Cocconi grappled with the concept of *magic frequencies,* those calling channels that Nature has carved into the cosmic bandplan, which would be obvious to any thinking creature on a planet orbiting any star. The assumption of mediocrity suggests that if we on Earth can figure out the bandplan, then our potential DX (being, we presume, more intelligent than we) will have figured it out as well. Morrison's and Cocconi's suggestion, the neutral hydrogen emission line at 1420.405751692 MHz, has been the starting point for nearly all the SETI searches that have followed. Hydrogen is, after all, the most abundant element in interstellar space, and it emits a clearly detectable, narrow-band calibration signal for all who care to tune its way. Surely if we can see that, so can *they.*

After nearly half a century of trying, though, we have yet to detect the interstellar CQ, on the hydrogen line or the myriad other magic frequencies we have monitored with Earth's best radio telescopes. Could it be we're listening on the wrong channel?

Peter Vekinis, LX1QF, thinks so. He speculates that advanced extraterrestrial civilizations will announce their presence in the millimeter-wave spectrum. Peter recently concluded two days of SETI observations from the 12-meter diameter radio telescope on Kitt Peak, Arizona. He selected ten frequencies between 115 and 177 GHz, associated with natural emission lines from molecules of biological significance on Earth. If organic processes are similar throughout the cosmos, Peter reasoned, then one or more of these frequencies might be obvious to the beings we seek to detect.

Peter's logic seems reasonable. If we are a typical example, then as civilizations advance technologically, they naturally gravitate toward ever higher frequencies. Yet the truth is that we're not all that advanced. It's easy for Earth's radio amateurs to monitor the 21-cm hydrogen line (after all, it's just up the road from the popular 23-cm ham band and our equipment tweaks up there quite readily). However, how many of us routinely tune the rarefied bands around 170,000 MHz? I venture to guess one could count them on the thumbs of one hand.



SETI League member Peter Vekinis, LX1QF, on site at the 12-meter diameter millimeter-wave radio telescope on Kitt Peak, near Tucson, Arizona, in November 2006 scanning for intelligent extraterrestrial signals. Peter conducted a two-day observing run in the 170-GHz spectral region. His raw data, recorded as audio .WAV files, was made available for SETI League members to download and analyze. So far, no signal of obvious intelligent extraterrestrial origin has been found buried in the mm-wave noise.

In just two nights of listening, Peter Vekinis recorded hundreds of gigabytes of noise. Somewhere, buried in that noise, he hoped to find ET, but sifting through so large a data set is a daunting task. To spread the workload among The SETI League's 1500 members, he put his data files on the web and encouraged his fellow members to apply their very best DSP techniques to the analysis. Several have risen to the challenge, although none has yet hit paydirt.

Recognizing that downloading of GB-size files requires a broader bandwidth than the connection most of us enjoy, The SETI League decided to make the entire data set available on DVD. These disks are provided free of charge to SETI League members in good standing. If you want to lend a hand, first join our grass-roots, membership-supported, nonprofit ham club via <http://www.setileague.org>. Include with your membership application a note saying, "send LX1QF DVD," and we'll respond as quickly as an all-volunteer organization is able.

Vekinis is fortunate to have occasional access to one of the world's great millimeter-wave radio telescopes. Most of us are not so blessed. Therefore, until KenYaeCom starts advertising mm-wave rigs in the pages of *CQ VHF,* chances are we'll all be stuck in the low microwave realm, hoping some benevolent extraterrestrial DX club will choose to put up a beacon on the Novice bands.

Still, when that first 170-GHz rig hits the market, I plan to buy one and join Peter Vekinis in listening on one of his magic frequencies. I hope you will, too. 73, Paul, N6TX

*Executive Director Emeritus, The SETI League, Inc.,
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e-mail: <n6tx@setileague.org>

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